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MAGNETISM.

DR. HOPKINSON, in his inaugural address to the Institution of Electrical Engineers, gave a very interesting and able account of the state of our knowledge of the subject of magnetism. He did well, we think, to confine his remarks to a small portion of the large field with which the Institution now deals.

Notwithstanding the great number of facts about magnetism that have been ascertained, we know very little about their ultimate explanation. Dealing more particularly with the magnetic properties of iron, nickel and cobalt, Dr. Hopkinson pointed out that between these and non-magnetic substances there was no continuity such as we find to be the case with most other natural properties. The intensity of magnetism was assumed to be measured by the current induced in a secondary coil wound round a ring of the magnetic substance. By this means the magnetic curves for different substance could be readily ascertained. The gap between the magnetic and the non-magnetic substances may be understood when we learn that the deflection given by iron at one point is 2,000 times as great as that given by a similar ring of glass or wood. The diamagnetic substances show deflections slightly less than the non-magnetic substances.

With the help of his ring with its primary and secondary coils Dr. Hopkinson explained very lucidly some of the other well known properties of magnetic substances. If the secondary coil be collected in one part of the ring it will make no difference to the total induction, and the halves of the coil may then be plucked apart to measure the intensity of any magnetism which may remain in the ring after the primary current has stopped. The phenomenon which Prof. Ewing has investigated and named Hysteresis can thus be shown. The descending curve of magnetism is found to be different from the ascending curve, and the area enclosed between the two curves represents the amount wasted in heat in a complete magnetic cycle. The energy lost in a complete cycle of reversals in Whitworth mild steel is 10,000 ergs per cubic centimetre, in oil-hardened steel 100,000 ergs per cubic centimetre, and in Tungsten steel 200,000 ergs per cubic centimetre. It is unnecessary to point out the importance of these facts in the construction of armatures. If an armature be made of wrought iron the loss by hysteresis may easily be less than 1 per cent., while with Tungsten steel it may be 20 per cent. In the case of transformers it becomes very important. The loss by hysteresis increases more rapidly than does the induction, hence it is not well to work the iron in alternate current machines to anything like the same intensity as in continuous current machines.

Perhaps the most interesting part of Dr. Hopkinson's address was that relating to the effect of temperature on magnetism; his own recent investigations on the critical temperature being of the greatest importance. Iron becomes non-magnetic at a red heat. With a small magnetising current the permeability of iron increases as the temperature rises to 770° C.; at 785° C. it is non-magnetic. If iron be magnetised when above the critical temperature, it retains the magnetism after it is cooled down below it. But the behaviour of an alloy of nickel and iron is still more interesting. This alloy, as received from the manufacturers, is non-magnetic at ordinary temperatures, but becomes magnetic below the freezing point. It remains magnetic when it rises again above the freezing point, and does not lose its magnetic properties till it reaches a temperature of 580° C. When cooled again, it is non-magnetic. Up to the critical temperature the electrical resistance of iron gradually increases, and then suddenly diminishes to that of a pure metal.

The most significant property associated with the critical temperature of magnetism is that of recalescence. A hard steel wire cooling down seems to undergo at the critical temperature of magnetism some change corresponding to the passage from the liquid to the solid condition, sufficient energy being given out to raise the temperature of the wire for the moment. The nature of the curves representing the cooling of

such wires have been determined by Dr. Hopkinson's ingenious experiments.

After discussing the theories of Poisson, Weber, and Ampère, Dr. Hopkinson came to the conclusion that they leave us in the dark as to the true explanation of magnetism; and concluded his address by throwing out the novel suggestion that all non-magnetic bodies may become magnetic when reduced to a sufficiently low temperature.

We should like to have heard some reference made by Dr. Hopkinson to other theories of magnetism, for instance, the ingenious theories propounded by Sir W. Thomson in his opening address to the institution last year, but, on the whole, we think that a more instructive and suggestive opening address has seldom been listened to by the Institution of Electrical Engineers.

THE DANGERS OF ELECTRIC LIGHTING.

CONTINUING their article on the above subject, in the last number of *Engineering*, Messrs. Ferranti and Ince endeavour to strengthen their case and to make out that "there are reasons why the dangers of electric lighting under a high pressure system are no greater, *if they are so great*, as those of a low pressure system." What these reasons are the authors certainly do not very clearly point out, and it is perhaps as well for themselves that they should leave their explanations somewhat indefinite; at the same time we must confess surprise, that arguing, as the writers are, for a case which it is difficult to support (and in our opinion cannot be supported) they should use such ridiculous clap-trap verbiage as that we have just quoted.

At the commencement of their second article the writers explain the construction of their concentric mains, and they state that it is impossible for anyone holding the outside sheath to receive a shock. This, no doubt, is true, provided the insulation remains good both in the main and at each end, but dealing with one particular class of fault does not justify the statement, that "whatever fault may occur, the whole effect is produced and contained in the main itself," and we have thus "a *perfect* protection for life and property from all forms of current." Continuing their reference to the mains, the writers speaking of the latter use the expression "properly constructed;" now this and the expression "properly joined," contains the very kernel of the whole matter, for there is no enterprise of any nature if "properly carried out" but must prove a *perfect* success. The difficulty (in many cases amounting to an impossibility) of "properly carrying" out work is what causes failures. No doubt, if over 264 joints in a mile of the concentric cable are all properly made, the durability of the cable is ensured, but anyone who has had experience of joints must know that anything approaching a set of perfect joints is a practical impossibility, and the greater the number the greater the difficulty; that one or several practically perfect joints can be made we do not doubt, but when we have a length which consists of a mass of joints the obstacles become enormous, and, we believe, are greatly underrated by Messrs. Ferranti and Ince. Speaking of transformers the writers state that "even if the current is sent out from the central station at a tension of 10,000 volts the tension is lowered at distributing stations by a suitable device, and that current the consumer has to handle is only at a pressure of 100 volts, and the pressure is so lowered and controlled *that by no possibility whatever* (the italics are our own) can the higher pressure get into any house." This statement seems to us very like a deliberate attempt to throw dust into the eyes of those for whom the article is written; the writers cannot but be aware that faults *have* occurred in transformers in which a much less tension than 10,000 volts has been used and the high tension *has* got into houses. If the transformer is "properly constructed" (!) of course the high tension cannot get to the secondary circuit, but to assume that faults cannot occur is simply childish nonsense. A great point is made with reference to the fact that the Board of Trade, "after seeing our work, have been perfectly satisfied to allow the Government to pass an Act which enables us to deal with a 10,000-volt current." This fact is exactly one which would greatly influence the ignorant public, as it would make it appear as if the Board of Trade advisers were thoroughly conversant with excessively high tension systems of lighting, and could therefore give recommendations based on experience; as a matter of fact the advisers can know nothing of how a 10,000 volt system would work, seeing that they have literally no experience to go upon. Towards the conclusion of this article the writers say, "We think we have said enough to show that the dangers of electric lighting are no more in the high tension system than the low, provided both systems are carried out with equal care and all proper safety devices are used in the one case and in the other." We, ourselves, do *not* think so, very far from it; say what the writers will, they cannot reasonably argue that *more* care is not required in the case of the high tension than in the case of the low tension system. Both require it, of course, but much more is necessary in the first than in the second case. Again, how does their statement, "provided both systems are carried out with *equal* care," agree with the assertion which we meet in the next paragraph, viz. "As the pressure increases *extra* precautions have to be taken with regard to safety." With one paragraph in the article in question of course no disagreement can take place, viz.: "The article shows that the saving of copper in the mains or conductors is enormous as the tension increases." This is the great point in favour of the high tension system, though it is not the only one. The use of the low tension system practically involves large engine rooms in the heart of cities where sites are expensive, and where the noise and vibration might be a serious nuisance. Did, however, the writers confine themselves to arguments of this kind there would be little to criticise, but they attempt to prove too much, and in so doing they are forced to use methods of reasoning which may deceive the public, but which will not stand fair analysis.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

THERE have been uttered, from time to time, complaints that the work of Telegraph Engineers has received but a scanty meed of attention at the hands of the governing body of the Institution of Electrical Engineers, and that a disproportionate amount of time and learning have been devoted to the applications of electricity and electrical engineering in other branches of industry. This may possibly be the case, but we would ask if telegraph engineers themselves are not in a great measure to blame for this condition of affairs? Apart from perhaps a lack of "push" evidenced by its professors and followers, may it not be that the business of telegraphy proper presents but comparatively few recent instances of invention, whereas we see from day to day fresh departures in electric lighting, propulsion, and transmission of power?

Be this as it may, it is rather unfortunate that when the subject of telegraphy has at length received some further notice a more substantial cause of grievance should be given. The speech of the past-president Sir William Thomson at the recent meeting of the Institution of Electrical Engineers is not very re-assuring to those who have at heart, in the interests of telegraphy, some higher aspirations than the mere question of £ s. d. Why, would we inquire, when referring to the history of the earlier Atlantic cables, should Sir Wm. Thomson so pointedly omit the mention of Sir Samuel Canning, and of other equally eminent pioneers; why should Captain Moriarty, R.N., to whom, as is well known, is due the merit of skillful navigation, be neglected? Possibly because these gentlemen have not sufficiently considered the necessity of self advertisement.

On the other hand, however, Sir John Pender and Sir James Anderson received a very sufficient measure of notice.

It seems strange that a scientific man such as Sir Wm. Thomson, intimately associated as he was with the leaders of telegraphic enterprise, should be only able to remember, and even then but inadequately, the commercial supporters of the adventure.

Whatever the source which provided Sir William Thomson with inspiration, whatever the motive which actuated him, we must regret that his speech was given a character so distinctly commercial; there would have been some interest in hearing more of the science connected with telegraphy and less of the dollars.

High Tension. What is It?

WE have received a letter from a correspondent couched in the following terms:—"By the way, what is your idea in so persistently and unreasonably running down high tension distribution? What is high tension, and why talk as if everyone who employed high tension—sensible people who use 1,000 to 2,000 volts—were in the same boat with an Italian who uses 10,000 volts? It's neither sensible nor scientific. Why not define your position clearly, and say if you don't believe in transformers and 1,000 to 2,000 volts, what you do believe in, and how distribution over large areas is to be effected without transformers? The casualties in America with overhead wires slung up anyhow gives no means of prophesying what will happen with underground wires and the work carried out most carefully." To this we add an extract from another communication:—"The recent mishap at Grosvenor Square has caused a considerable flutter in insurance circles. It is now found that the high tension primary entered no less than six houses at the time of the fire at No. 8, destroying the converters, blowing out the fuses and breaking the lamps. Fortunately only at one was serious damage done, and fortunately, also, nobody was hurt. In several of the instances the electricity was seen to play about the casing and fittings like lightning, and in one case, in Park Lane, has left its mark on the ceilings. Mr. Heaphy's "*independent*" report says nothing of these mishaps. Mr. Preece has reported for the fire offices, and attributes the damage to an earth on the primary, aggravated, no doubt, by the wretched wiring of No. 8. If report be true, this circuit was on from Deptford, and for some cause or other considerably more than 2,400 volts reached the house transformers! We are likely to have a lively time of it from the "London" unless Mr. Ferranti mends his ways."

Transformers.

NOW we will say a few words in reply to our correspondent who misinterprets our views on the subject. It is not necessary for us to define high tension; that has been done by the Board of Trade, notably in our issue of last week. Nevertheless, we do think that with 2,000 volts the difficulty of insulating the primary from the secondary coils on a transformer will prove very great if these apparatus are to be highly efficient, for to this end it stands to reason that the covering of the wires must be kept as thin as it is possible to make it. Those who have watched the working of converters in the States with only a potential difference of 1,000 volts, need not be reminded of the number of times they have been rendered useless by burning out, and we are convinced that in these instruments alone much trouble will be experienced. There are two other means of distribution over large areas by continuous currents, to neither of which the objection we have mentioned can be applied, and to make electric lighting absolutely reliable we require to, and in the end we must, store electrical energy. Even the opponents of secondary batteries cannot but admit that this is the one thing necessary to place the new illuminant on the same footing as gas, and the recent strike of the South Metropolitan Gas Company's men ought to bring this forcibly home to the electrical fraternity, for without the ample storage capacity possessed by Mr. Livesey's works, what would have been the result in a few hours time? Whether conductors are underground or overhead does not affect the question of the converters, and although earthing devices are well enough in their way, consumers would not long allow themselves to be subjected to the cutting off of their supply of light by the little vagaries of the transformer.

Science and Bold Advertisement.

THE *English Mechanic and World of Science* is widely read by a class of men ranging from the professor to the merest tyro. Such being the case, we are somewhat surprised to see in its pages an advertisement of the

Electropathic kind, the bulk of the matter being, we do not hesitate to say, a tissue of absurdities. In scientific matters, as in any other, a little knowledge is a dangerous thing, and probably many of those who scan our contemporary's pages from week to week have not yet become such storehouses of knowledge as to be able to sift the grain from the chaff.

American *versus* English Motors.

DR. LOUIS BELL, in an interesting communication on "Tests of the New Sprague Street Railway Motor," dwells upon the disadvantages of the single magnet motors, and says that "American practice in this respect seems to be quite different from English practice, where a double magnetic circuit with consequent poles and an armature relatively quite powerful seems to be the rule, and this form of motor, such as is used by Reckenzaun and Immisch, weighs, for equal power, only about half as much as the American form, while its electrical efficiency is quite as great." Dr. Bell advises his countrymen to change the design accordingly.

Electricity in England.

THE New York *Herald* (London Edition) of the 12th, has a flaming article on this subject. Quoting from a contemporary, the writer says: "the editor of the *Electrician* says that 1889 will long be memorable in the annal of electric lighting in England as one in which was witnessed an outburst of electrical activity, rivalling to some extent the great railway mania of 1846." Our contemporary occasionally indulges in somewhat rhapsodical utterances, and in the present instance it is excusable, for its youthful editor can scarcely have even a faint recollection of what took place over 40 years ago; let us hope, however, that the year of grace 1890 will not witness an equally sudden collapse of much of its predecessor's active outburst.

Inductive Effects.

WE would like to know how the Ferranti system of high tension alternating currents will affect telegraph instruments or other electric apparatus which are dependent upon alternating currents for their operation, and within the inductive influence of the Deptford mains, say, for instance, a Wheatstone Alphabetical Instrument or Automatic Receiver? The time is not far distant when somebody must get up a discussion upon such topics before the Institution of Electrical Engineers, and who could do it better than the chief electrician to the Post Office?

Useful Data.

IT is pretty generally known that we are not enthusiastic champions of Mr. Edison or of everything he does, but there is much truth in certain portions of his recent onslaught against high tension, and whatever objections are tenable in criticising American practice ought to tell with increased force on this side. From the very nature of things much is tolerated in the States which would not be allowed to go on here, therefore when systems are shown to be highly dangerous in a country where long distance transmission and distribution over large areas appear to be absolute necessities, that danger seems to be intensified in a community where the same pressing needs do not exist. Mr. Edison might with advantage select one of his assistants to secure reliable data of the number of transformers which are in use in his own land, the length of time the best of them withstand the effects of 2,000 volts alternating, and the number of instances on record of their burning out or being rendered useless. Such information as this, leaving entirely out of the question the fatal accidents which high tension systems have caused, would give English electricians, who are only feeling their way, a fair idea of what might be expected in the long run.

Save me from my Friends.

THE letter which we publish from Mr. Richardson touches somewhat upon the subject of an article in our leading columns, and shows clearly enough that we are not alone in our opinion of the Ferranti-Ince papers in a contemporary. Naturally the majority of people who have electric lighting interests at heart sympathise with Mr. Ferranti in his great undertaking, but enthusiasts do not always discriminate between practicable ideas and sheer impossibilities. If he fails it will be mainly because none of his so-called friends—and we know some who do not, when away from his influence, see how he can possibly achieve an unqualified success—had the courage to frankly express their fears.

Electric Light in Cotton Mills.

A circular has been issued by the Corporation of Blackburn giving collected particulars as to the use of electricity in cotton mills. Opinions have been received from America and almost every European country. Electricity in cotton mills is naturally applied in England to a greater extent than elsewhere on account of the cotton industry in England being of greater proportions. A most unanimous feeling is expressed on the subject by English manufacturers in favour of the illuminant. One large firm expresses its conviction as follows: "Find the electric light a great improvement in every way on gas. Consider it healthier for the workpeople and a very good light for weaving coloured goods." Weaving sheds have been fitted with installations in Germany with very favourable results. Prudent manufacturers, we notice, have only in use the incandescent lamps, considering arc lamps attended with a certain amount of danger. We are of opinion that the circular will serve a most useful purpose, in bringing before the cotton industry the advantages already experienced in the use of the electric light.

New Accumulator.

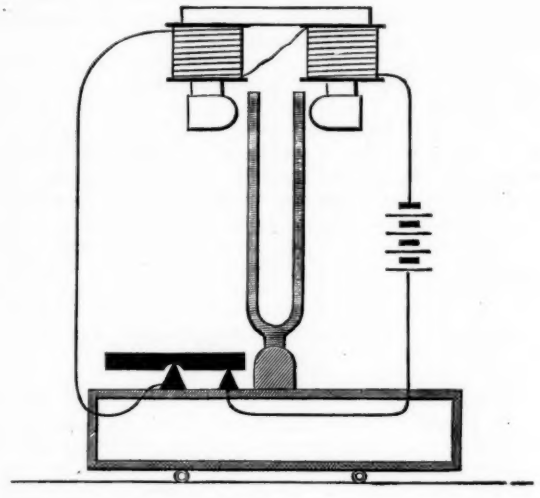
IT is rumoured that Messrs. Drake and Gorham are about to introduce a new secondary battery which is highly spoken of. The apparatus hitherto used has many advocates, and every improvement on it will bring over fresh adherents; we trust, therefore, that rumour speaks correctly, although if it is the Dujardin accumulator we do not anticipate any marvellous results.

Exhibitions.

IT is said that the opening of the proposed Frankfort-on-Maine Electrical Exhibition has been postponed till May, 1891. This, we believe, to be a wise policy on the part of the promoters, for as we said last week, the Edinburgh show might have clashed with the Continental one.

A NEW METHOD OF ELECTRICALLY DRIVING TUNING FORKS.

A VERY small weight added to the prong of a tuning fork is sufficient to alter its tone both in quality and in pitch. Hence the metallic contact-piece in electrically driven forks has been to some extent a defect. We illustrate a means of driving a tuning fork electrically, devised by Mr. R. Appleyard, of Cooper's Hill College, which leaves the prongs free. The fork is mounted upon a resonating box; a small microphone, attached to the top of the box, vibrates with it, and, adapting itself to the period of the fork, causes the current through the magnets to vary synchronically as required.



The microphone consists of two blocks of carbon of triangular section, rigidly fixed to the box, and a third, of square section, which is so nearly balanced upon one of the V-edges as to rest but lightly upon the other.

A notch is filed in the carbon rod at its balancing point.

It is interesting to observe that the same microphone has served for forks of different pitch—the deep bass F and the middle A, for instance.

ELECTRICITY IN IRELAND.

THE employment of electricity for lighting and power purposes has not yet made very great progress in Ireland, the development of these two branches taking place but slowly. This is partly due to the lack of capital on the part of the inhabitants, and partly to the want of enterprise shown by them. In some of the northern counties small arc and glow lamp installations have been put up in different bleach works, spinning, and scutching mills, distilleries, clubs, shipbuilding yards, &c., whilst a few examples may be found in the midland and southern counties.

Now, however, an enterprising firm in Dublin, Messrs. Box & Co., of Abbey Street, have formed a central electrical engineering company for the purpose of carrying out all kinds of electrical work. In their large establishment they have entirely given up the use of gas, and have taken down their fittings, the electric light being substituted. The installation is very remarkable, having been put up expressly with the object of illustrating the various modes of electric lighting. For this purpose, the installation has been divided into five sections of, together, 300 glow lamps, and this has consequently made the expense considerably greater. The first section comprises a set of accumulators which are charged during the day by a dynamo which has been constructed on the premises. The second section consists of 100 lamps, the current for which is furnished by a Crompton dynamo, driven by a Stockport gas engine. A Statter dynamo for 90 lamps is employed in the third section, and the machine is actuated by a steam engine. In the fourth section another battery of accumulators is installed, and these will supply current to the lamps fitted up in the bridle workshops, machine rooms, and in the front portion of the establishment. The fifth section comprises the show room of the Central Electrical Company. This room is furnished with different kinds of fittings, brackets, &c., and when the lamps are lighted a very pleasing effect is caused.

Turning to another department of the establishment, we find a narrow gauge railway running through the factory, and carrying the metal castings from the foundry to the finishing shops, and distributing the heavy goods generally. This railway it is proposed shortly to work by means of electricity. The firm print most of the stationary required in their business, and the printing press is driven by an electric motor which has been made on the premises. This is the first instance of a printing press being worked by an electric motor in Ireland, although there are a few such cases in England. Probably this installation is unique of its kind, as there are scarcely any instances on record where are employed different makes of dynamos and engines, both steam and gas, and where the lamps are run direct from the dynamos and from accumulators, the lamps being also of different voltage. This step has, of course, as already mentioned, been taken in order to demonstrate what can be done by one kind of plant, and what can be effected by another. The innovation deserves to turn out a success for the company in the advancement of electric lighting, as such demonstrations are, with the exception of at exhibitions and at stations not open to the public, very rarely made accessible to the general community.

ON THE "NEW" PRINCIPLE OF CONSTRUCTING ELECTRIC MOTORS.

MR. C. O. MAILLOUX, an American engineer of high reputation, who has had a wide experience in electric traction, contributes an article to the *Electrical World*, of December 28th, in which he sets forth his views on motor design, drawing comparisons between the methods and the theories of Tesla, Ayrton and Perry, Mordey, Snell, Reckenzaun and Dr. O. Froehlich, of which we give the following abstract:—

"There are probably many designers of electric motors to whom the "new principle" advanced by Mr. Nikola Tesla, in a recent issue of *The Electrical World*, will be of no great surprise, unless the surprise consist in finding the statement thereof at this late day, unaccompanied by the proper limitations.

"That 'circumstances alter cases' is one of the first things that the electrical engineer realises, and quite strongly, too, in undertaking to design electric motors for various purposes. He soon learns, indeed, that the designing of an electric motor is literally the solution of a very complex problem, involving numerous factors, which, to use a mathematical phrase, are functions of almost countless 'independent variables.'

"To enumerate a few of the conditions only, the designer has such things as the source and character of current supply, the kind of work, the capacity, speed, range of load, regulation, efficiency, weight, size, space occupied, mechanical simplicity, and cost of construction of the motor to keep before his mind in designing.

"Considered with reference to each particular case (which must of necessity be done), these requirements might be classed (in order of relative importance) in three groups—viz., indifferent, desirable and indispensable. The 'grouping' is, moreover, different for each case, and the relative positions of various conditions may even find themselves reversed. Thus, for example, in a stationary motor, smallness of size and reduced

weight are of relatively indifferent consideration, but in a street-car motor they are indispensable requisites.

"These changes of relative importance react upon the design, and though not necessarily influencing the *type*, they do control absolutely the *proportions* and engineering details. Now, the relative and respective proportions of field magnet and armature in a given motor are among those factors which must be considered as 'dependent' upon the requirements just noted. According to the relative importance ascribed to the requirements, or according to their 'grouping,' as just stated, this proportion will vary.

"It depends largely upon which of the desirable qualities the designer concludes to sacrifice, in order to secure what is, on the whole, the most expedient and advantageous for any particular purpose or application. Thus in 1883 we were informed on good authority —Profs. Ayrton and Perry—that the magnetic proportions of a motor should be 90 per cent. armature and 10 per cent. field magnet. In 1887, we learn on equally good authority—Mr. W. M. Mordey—that the proper proportions should be just the reverse, or 90 per cent. field and 10 per cent. armature. Mr. Tesla now claims that the right course lies half-way between these two extremes, and that the proper proportion is obtained by giving to the field and armature equal magnetic moments.

"This whole matter was quite clearly and forcibly put forward in England by Mr. Albion T. Snell, in a paper entitled, 'Notes on the Design of Electric Motors,' read January 16th, 1889, before the City and Guilds Old Stndents' Association. This paper, let me say in passing, constitutes, together with the discussion thereon, one of the ablest recent contributions to the knowledge of the theory and practice of electric motor design, and would have been well worth reprinting in American journals.

"Mr. Snell shows that the proportions depend on many conditions and circumstances, and that no absolutely fixed rule can be determined; that incidental or accidental questions of cost and mechanical construction, &c., may vary the proportions, as the size and capacity of the motor vary. In some cases he would grant that Mr. Mordey was right; but in others he would go in the opposite direction with Profs. Ayrton and Perry. If, as we presume, we can take the 'Immisch' motors to represent the practice of the doctrines he preaches, he does not, it would seem, approach either extreme, but oscillates, as it were, on either side of the half-way course. This is because he lays great stress upon 'weight efficiency,' and designs his motors from the *torque* or turning moment, as a starting point.

"Now, passing on to portable motors for traction, hoists, &c., the proportions would gradually approach the point set by Mr. Tesla, and if the speed and load varied within wider limits still, *this point would even be passed*, and the proportions would approach the point set by Profs. Ayrton and Perry. During this transition, the design would undergo considerable changes in proportion, and would experience a corresponding change in quality by graduations. We would find that we had gained in certain qualities and lost in others. If we could properly and fully estimate the value of all advantages and disadvantages, we would probably find that the net aggregate sum was nearly constant, within wide changes of proportions. So that the whole effect of successful designing lies in the art of knowing or finding out which qualities to emphasise and which to sacrifice, in order to obtain maximum results under given conditions.

"Returning now more particularly to the question of the ratio between magnetic moments in field and armature, the principle formulated by Mr. Tesla is in reality a statement of the fact that when *torque* is the great desideratum, or the quality to be emphasised, even at the expense of certain considerations (perhaps including efficiency), but without sacrificing lightness, then the 'maximum' is reached when the magnetic moments are made equal in field and armature. Mr. A. T. Snell, in the paper just noted, lays great stress on the torque as being, so to speak, the 'natural' starting point in motor design. Hence it is presumable, and his practice indicates, that he must be fully aware of the conditions under which the maximum obtains. The first one, however, who seems to have grasped and applied this principle of maximum torque is, so far as the writer is aware, Mr. Anthony Reckenzaun, in England, who seems to have started from the Ayrton and Perry 'limit,' and worked back to the 'middle' point. For several years Mr. Reckenzaun has designed his traction motors substantially on these lines. I have already expressed the opinion that such a design appears well suited to portable motors. Personal experience leads me to believe that it is also well suited to the purposes of street car traction.

"Dr. O. Froelich has also put the question quite clearly in his work on 'The Dynamo-Electric Machine' (1886). The following is a liberal translation from a paragraph entitled, 'On the proportion of the respective windings of the field and armature':—

"'In seeking the best possible winding for an armature, one is faced by two problems of almost contrary natures, viz: the *electrical capacity* required of the machine, and the *proper working of the commutator*. If it were merely a question of obtaining for a given weight and speed the greatest possible capacity, one could scarcely increase too much the space allowed for the armature winding and the weight of wire. But the designer soon observes that as he puts on more wire the sparking of the commutator and the wearing away of both commutator and brushes increase. Now, since the deterioration is of foremost importance from the practical point of view, the designer is forced to restrict the amount of wire on the armature to the limit imposed by this circumstance.

"'It is almost impossible to set, in a general way, a minimum value to this amount of wire; all depends in that regard on the special qualities of the type of machine under consideration. Experience alone can furnish exact data on the subject, and exhaustive researches alone can guide the designer in this path and determine the amount of wire suitable for the machine which he is constructing.'

"Some two years ago, having to design some motors for street-car traction purposes, to be used as is now the general rule, with a *constant* gearing ratio, the *torque* required at different speeds and under different conditions was made the starting point of calculation, precisely as since recommended by Mr. Snell in his paper. Reasoning from simple cases, such as conductors or magnets reacting upon each other, the conclusion was soon reached that the torque would depend upon the combined effort of both field and armature magnetism. When opportunity presented, the experimental demonstration was made.

"'March 23rd, 1888.—I made an experiment yesterday with a small 'C. and C.' motor, to test the influence of the ampère-turns of the field and armature *on the torque*. The current was first passed through both field and armature in the ordinary way, and the pull on the lever noted for different currents. Then the current was made constant in the field and varied in the armature. From the data the curves made show that the torque increases with the current in *both*, as reasoning would lead one to expect. I tried the experiment on purpose to satisfy myself regarding the advantage of increasing the number of *turns on the armature*, contrary to the accepted doctrine that a good dynamo is a good motor, for it is well-known that, in dynamos, practice is drifting in the direction of putting only a few turns on the armature, and strong field coils. I reasoned that in a motor that is to give maximum torque, this would be wrong. The motion, or tendency thereto, is the result of the field's distortion, by the deflecting power of the armature coils, whose tendency is to make poles at the neutral point, or in a line of polarity at right angles to that which the magnetic field of the field coils produces. *I look upon the phenomenon* as one *where the armature forcibly pulls the field of the field magnets out of their axial line, leaving them* (lines of force) *to rebound* or spring *by causing motion of the armature.* Consequently

the moment exerted depends not only on the power of the field magnet but on that of the armature. . . .' The sentence which is here italicised is merely a passing reference to my views regarding the nature of the reactions taking place in an electric motor, which I conceive to be a process whereby energy (electro-kinetic) is abstracted from the electrical circuit to forcibly displace lines of magnetic force temporarily, the energy thereby stored in the form of elastic tension being conveyed or transmitted immediately after to the moving part of the motor, as the lines of force fall back to their original stations by virtue of this tension.

"It is clear first, that the torque can be increased just as well by increasing the armature ampère-turns as by those of the field magnet, the two methods giving very nearly the same results. Second, that the best result would be obtained by increasing the magnetic powers of both field and armature equally."

A NECESSITY OF THE AGE.

THE continual dropping of water wears away stone. If you only throw enough mud, some will stick. Mr. Pears must find people believe his soap to be the best simply because he persistently says so, or he would not go on saying it at considerable expense. We like to have our minds made up for us, and to learn what to eat, drink, and avoid, as we run. Reiteration is a great evangelist. Comic writers have a knack of repeating the same word, sentence after sentence, until we look upon it as a good joke, and laugh. We forget the verses of a song, but remember its chorus. Line upon line, precept upon precept, still is sound advice. Denounce, denounce, denounce, and the idea or the reputation is killed. Praise, praise, praise, and the nostrum sells. It is no good cavilling at eternal laws: run with them, and bend them to your use. By so doing you not only are a blessing to your fellow man, but, what we are afraid you do not sufficiently consider, and what you really ought to think of, you benefit yourself.

It is a very long time ago since the world first saw the words, "Electricity is life." A philanthropist, at his own cost, has told us this daily all those years in the public Press. We verily believe, and with humility we own it, that more thousands of the human race have been affected by this simple short announcement; that more of them have had burnt into their brains thereby the belief in the force of electricity than by the studiously thought out, carefully edited, and news-giving columns of ourselves and *confrères*. "How can they believe unless they hear, and how can they hear without a preacher?" Numbers of well-informed persons know, even now, absolutely nothing about electric lighting, who are suffering in eyes, head, and lungs from the use of gas, and would willingly pay somewhat more for pure electric rays. They do not know how really cheap it is in the end, and how easily put into their homes. We may have our little joke at our American cousin, but no one ever accused him of not having an eye to his own interests. Look at the pages of his electrical journals, and count the number of those which are covered with advertisements. These announcements are in themselves a liberal education. Therein you learn all about electrical manufactures and lighting companies, and discover that all are the best, and so one is as good as another, and you can make no mistake. Those who know best, say that erratic insertions are of little use, but that continuous advertisement pays. In the country where there is the most of it there is most electric lighting; not entirely due to it, doubtless, but assuredly owing some of its activity thereto.

Electric Railway in Germany.—An electric railway will shortly be made between Elberfeld and Barmen, in Germany.

THE ELECTRIC LIGHT IN BUDA-PEST.

[FROM A CORRESPONDENT.]

YOU have recently published an extract from the proposals of the Buda-Pest Gas Company to this city with respect to the electrical lighting of Buda-Pest. The Municipal Director of Buildings (an official somewhat intermediate between the Borough Engineer of an English town and the Dean of Guild of a Scottish municipality) issued his report, and it will be of interest to your readers to learn the position which the City of Buda-Pest takes with reference to the offer of the gas company. We extract the following points from the copious and elaborate report:—

The agreement of the gas company expires on December 16th, 1895, and with it the right of the company to the public lighting, but it still *may* supply gas to private consumers without fixed prices. For this right there is paid to the city, in the first ten years, 5 per cent; in the second, 7½ per cent.; and in the third, 10 per cent. of the nett proceeds. The exclusive right of the gas company to the private lighting expires in December, 1891. If the city does not denounce the agreement in the year 1893 it is to be considered as prolonged for ten years, but the city would then be entitled to 30 per cent. of the net profit over and above 10 per cent. But the city has not the power to ascertain the balance. As a decrease of the income cannot be expected after the adoption of the much more expensive electric light, a simple prolongation of the agreement cannot be accepted any more than a concession of the private lighting, together with the existing net of pipes, and other appliances. Unless the conditions can be essentially modified to the benefit of the city, the taking over of the entire gasworks seems most advisable, and therefore a test valuation should be undertaken in 1892; not earlier, as the company is still making further investments. Of whatever kind the future arrangements between the company and the city may be, so long as they are not arranged, the efforts of the authorities should be turned to the redemption of the gasworks, as this everywhere gives the most satisfaction to the public.

The offer of the gas company, concerning the electric lighting of single streets, is pronounced not acceptable, from the following reasons:—

1. The lighting is, on account of the peculiar conditions, dearer than anywhere else (*e.g.*, in Vienna).

2. Because the company demands for the first ten years an exclusive right not merely to the lighting, but to the entire installation.

3. Because it stipulates fixed prices for the entire time of the agreement, and, in view of the probable improvements and consequent reduction in the cost of production and distribution, it concedes no benefit to the city.

4. Because the measure of electric light demanded by the public, from an æsthetic point of view, can be obtained within the scope of the existing agreement, as the number of the gas lamps available for a very small compensation, or without any at all, is sufficient. In case of need, this partial illumination can be committed to another company.

The licenses for private lighting from the street-mains should be put off until the right of the Company expires in the year 1891.

It is to be remarked that the electric light is generally more costly than gas-light, and the more brilliant and beautiful light demands a corresponding sacrifice. The offer of the Gas Company to furnish the public lighting gratis, involves conditions out of proportion to the benefits expected, from the following reasons:—

1. With a ten years' exclusive privilege, and a redemption after 50 years, the entire lighting would be in effect confiscated.

2. For all the advantages which would accrue to the Company from having both kinds of lighting in their hands, it offers merely the gratis consumption of gas for the number of lamps of the year 1888, whilst to private consumers the price will be successively

diminished, but only to 11 kreuzers per cubic metre, which in the future may become less advantageous than the present agreement.

As it stands the offer is therefore not acceptable. The negotiations may be continued with the Company always on the basis of a gratuitous street lighting, with the endeavour that the price of 11 kreuzers cannot be taken as a minimum, and if this is a fundamental condition it can be carried out only by relinquishing the electric lighting.

The conditions of the electric lighting must be modified so that no exclusive right is granted and the unitary price must be reduced.

THE MANCHESTER EDISON-SWAN COMPANY.

THE Manchester Edison-Swan Company has been very fully employed during 1889. In the early part of the year it completed a central station on the low tension system at St. John's, Newfoundland, the Houses of Assembly, the Government House, and other buildings being lighted. Installations, many of large size, have been erected in the mills and works of the undermentioned firms:—Messrs. Larios Brothers, Malaga and Gibraltar; the Union Mill Company, Rochdale; Harington and Eckersley, Wigan; Sladen Wood Mill Company, Littleboro'; Amsworth Brothers, Bolton; Textile Mill Company, Oldham; J. Mandleberg and Co., Pendleton; Wilde and Booth, Denton; J. and J. Mellor, Bury; Slaut, Guyer and Spitz; Cannington and Shaw; Yates and Kay; and many others. The whole of the extensive premises of the Bolton Co-operative Society have been entrusted to the company, and the installation at the Pavilions, at Castle Mona, Douglas, and Llandudno, with the pier at the latter place, have also been carried out by them. Among private houses and hotels those of Albert Wood, Esq., Conway; Jno. Walker, Esq., Llandudno; the St. George's Hotel, Llandudno; the Osborne Hotel, Bradford; Palace Hotel, Birkdale; and the five Manchester Limited Restaurants may be mentioned. The company have also carried out numerous wiring installations for central station works in shops and offices. At the present time they have in progress installations for Messrs. Calvert & Co., the Kellner Partington Wood Pulp Company, Cormbatori Mill Company, Langdale & Co., Fletcher, Burrows & Co., Atherton, and others.

Some idea of the progress of electric lighting in this district may be gathered from the fact that during the past year this company has supplied something like 40,000 incandescent lamps, and the present outlook is a very satisfactory one.

REVIEWS.

Electric Light, its Production and Use; Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators and Electric Lamps. By J. W. URQUHART. Third edition, carefully revised, with large additions. London: Crosby, Lockwood and Son.

Compared with the first edition the present issue of Mr. Urquhart's book conveys a most favourable impression, it is a vast improvement on the original work. From a critical point of view very little can reasonably be said against it, whilst there is much to be commended. The book occupies an intermediate position between an elementary and an advanced work, and may perhaps be termed an advanced popular treatise. The whole ground of electric lighting is more or less covered, accumulators, transformers, meters, &c., being referred to, illustrated and explained in a very clear and concise manner. In one or two places a little extra revision seems necessary; thus at the commencement an illustrated explanation of "series" and "parallel" joining up of battery cells might with advantage be added. At the termination we observe it stated that a "kilowatt" means a "thousand watts for *one hour*," this, however, may possibly be only a slip on the author's part.

Journal of the Institution of Electrical Engineers, No. 82. London: E. and F. N. Spon.

The general contents of this number are as follows:—"The Lighting of the Centennial International Exhibition, Melbourne, 1888 and 1889," by K. L. Murray, Member; "Electrical Engineering in America", by G. L. Addenbrooke, Associate; "Abstracts"; and a classified list of articles relating to electricity and magnetism appearing in the principal English and foreign technical journals.

Practical Notes for Electrical Students. Vol. I., Laws, Units, and Simple Measuring Instruments. By A. E. KENNELLY and H. D. WILKINSON. London: "The Electrician" Printing and Publishing Company, Limited, 1, Salisbury Court, Fleet Street.

This book is mainly a reprint of a series of articles which appeared in the *Electrician* under the title of "Letters for Learners and Unprofessional Readers." The 9 chapters into which the work is divided are respectively, "Introductory," "Batteries," "Electromotive Force and Potential," "Resistance," "Current," "Current Indicators," "Simple Tests with Indicators," "The Calibration of Current Indicators," "Magnetic Fields and their Measurement," "Tables." The book, we think, thoroughly well fulfils its title, and though, perhaps, here and there it lacks originality, there is very much matter that is extremely useful, especially in the chapter (a lengthy one) dealing with "Magnetic Fields and their Measurement." Mr. Wilkinson hints that he may at some future time continue his work, and we think that students would be greatly benefited if he were to do so.

Mechanical Graphics. A Second Course in Mechanical Drawing. With Preface by Prof Perry. By GEO. HALLIDAY. London: E. and F. N. Spon.

This book illustrates part of the course of instruction for first year students at the Finsbury Technical College. A special feature in the work is the treating together of the subjects of Practical Plane Geometry, Practical Descriptive Geometry, Graphical Statics, the loads on the parts of hinged structures, and Calculations on Link Motions and other forms of Valve Motion. The general contents are as follows: "Plane Geometry," "Orthographic Projection," Sections of Solids," "Curves," "Traces of Lines and Planes," "Tangent Planes," "Interpenetration of Solids," "Shadows," "Isometric Projection," "Perspective Projection," "Graphical Statics," "Valve Motions." The importance of a good knowledge of mechanical drawing is very great, though a satisfactory acquaintance with free hand is almost as necessary, and, unfortunately, is far less extensive than it should be. Taking Mr. Halliday's work as a whole we are very pleased with it, and consider that it well carries out its object. The illustrations are carefully and clearly executed.

Such is Fame.—The *Daily Chronicle* of last Friday, thus gives the names of three well-known gentlemen in electrical circles: Sir John Pinder, Dr. Hopkins, and Mr. Priest. We have often noticed the name of the presiding genius of the postal telegraphs spelled in in this way, perhaps because he is looked upon in some quarters as the "high priest" of certain things electrical.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

"Magnetism," the Inaugural Address delivered by J. HOPKINSON, M.A., D.Sc., F.R.S., President, January 9th, 1890.

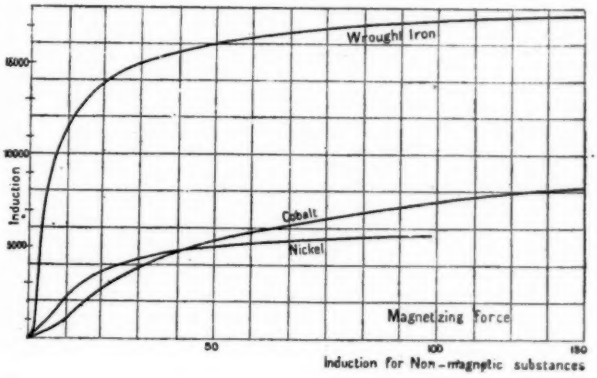
As old as any part of electrical science is the knowledge that a needle or bar of steel which has been touched with a loadstone will point to the north. Long before the first experiments of Galvani and Volta the general properties of steel magnets had been observed—how like poles repelled each other, and unlike attracted each other; how the parts of a broken magnet were each complete magnets with a pair of poles. The general character of the earth's magnetism has long been known—that the earth behaves with regard to magnets as though it had two magnetic poles respectively near the rotative poles, and that these poles have a slow secular motion. For many years the earth's magnetism has been the subject of careful study by the most powerful minds. Gauss organised a staff of voluntary observers, and applied his unsurpassed powers of mathematical analysis to obtaining from their results all that could be learned.

The magnetism of iron ships is of so much importance in navigation that a good deal of the time of men of great power has been devoted to its study. It was *the* scientific study of Archibald Smith; and Airy and Thomson have added not a little to our practical knowledge of the disturbance of the compass by the iron of the ship. Sir W. Thomson, in addition to much valuable practical work on the compass, and experimental work on magnetism, has given the most complete and elegant mathematical theory of the subject. Of late years the development of the dynamo machine has directed attention to the magnetisation of iron from a different point of view, and a very great deal has been done by many workers to ascertain the facts regarding the magnetic properties of iron. The upshot of these many years of study by practical men interested in the mariner's compass or in dynamo machines by theoretical men interested in looking into the nature of things is that, although we know a great many facts about magnetism, and a great deal about the relation of these facts to each other, we are as ignorant as ever we were as to any reason why the earth is a magnet, as to why its magnetic poles are in slow motion in relation to its substance, or as to why iron, nickel, and cobalt are magnetic, and nothing else, so far as we know, is to any practical extent. In most branches of science the more facts we know the more fully we recognise a continuity in virtue of which we see the same property running through all the various forms of matter. It is not so in magnetism; here the more we know the more remarkably exceptional does the property appear, the less chance does there seem to be of resolving it into anything else. It seems to me that I cannot better occupy the present occasion than by recalling your attention to, and inviting discussion of, some of those salient properties of magnetism as exhibited by iron, nickel, and cobalt—properties most of them very familiar, but properties which any theory of magnetism must reckon with and explain. We shall not touch on the great subject of the earth as a magnet—though much has been recently done, particularly by Rücker and Thorpe—but deal simply with magnetism as a property of these three bodies, and consider its natural history, and how it varies with the varying condition of the material.

To fix our ideas, let us consider, then, a ring of uniform section of any convenient area and diameter. Let us suppose this ring to be wound with copper wire, the convolutions being insulated. Over the copper wire let us suppose that a second wire is wound, also insulated, the coils of each wire being arranged as are the coils of any ordinary modern transformer. Let us suppose that the ends of the inner coil, which we will call the secondary coil, are connected to a ballistic galvanometer; and that the ends of the outer coil, called the primary, are connected, through a key for reversing the current, with a battery. If the current in the primary coil is reversed, the galvanometer needle is observed to receive a sudden or impulsive deflection, indicating that for a short time an electromotive force has been acting on the secondary coil. If the resistance of the secondary circuit is varied, the sudden deflection of the galvanometer needle varies inversely as the resistance. With constant resistance of the secondary circuit the deflection varies as the number of convolutions in the secondary circuit. If the ring upon which the coils of copper wire are wound is made of wood or glass—or, indeed, of 99 out of every 100 substances which could be proposed—we should find that for a given current in the primary coil the deflection of the galvanometer in the secondary circuit is substantially the same. The ring may be of copper, of gold, of wood, or glass—it may be solid or it may be hollow—it makes no difference in the deflection of the galvanometer. We find, further, that with the vast majority of substances the deflection of the galvanometer in the secondary circuit is proportional to the current in the primary circuit. If, however, the ring be of soft iron, we find that the conditions are enormously different. In the first place, the deflections of the galvanometer are very many times as great as if the ring were made of glass, or copper, or wood. In the second place, the deflections on the galvanometer in the secondary circuit are not proportional to the current in the primary circuit; but as the current in the primary circuit is step by step increased we find that the galvanometer deflections increase somewhat as is illustrated in the accompanying curve (fig. 1), in which the abscissæ are proportional to the primary current, and the ordinates are proportional to the galvanometer deflections. You observe that as the primary current is increased the galvanometer deflection increases at first at a certain rate; as the primary current attains a certain value the rate at which the deflection increases therewith is rapidly increased, as shown in the upward turn in the curve. This rate of increase is maintained for a time, but only for a time. When the primary current attains a certain value the curve bends downward, indicating that the deflections of the galvanometer are now increasing less rapidly as the primary current is increased; if the primary current be still continually increased, the galvanometer deflections increase less and less rapidly.

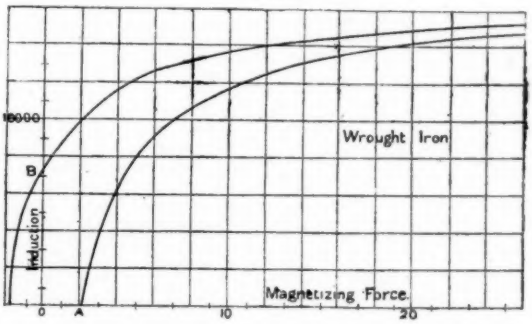
Now what I want to particularly impress upon you is the enormous difference which exists between soft iron on the one hand, and ordinary substances on the other. On this diagram I have taken the galvanometer deflections to the same scale for iron, and for such substances as glass or wood. You see that the deflections in the case of glass or wood, to the same scale, are so small as to be absolutely inappreciable, whilst the deflection for iron at one point of the curve is something like 2,000 times as great as for non-magnetic substances. This extraordinary property is possessed by only two other substances besides iron—cobalt and nickel. On the same figure are curves showing on the same scale what would be the deflections for cobalt and nickel, taken from Professor Rowland's paper. You observe that they show the same general characteristics as iron, but in a rather less degree. Still, it is obvious that these substances may be broadly classed with iron in contradistinction to the great mass of other bodies. On the other hand, diamagnetic bodies belong distinctly to the other class. If the deflection with a non-magnetic ring be unity, that with iron, as already stated, may be as much as 2,000; that with bismuth, the most powerful diamagnetic known, is 0·999825—a quantity differing very little from unity. Note, then, the first fact which any theory of magnetism has to explain is: Iron, nickel, and cobalt, all enormously magnetic; other substances practically non-magnetic. A second fact is: With most bodies the action of the primary current on the secondary circuit is strictly proportional to the primary current; with magnetic bodies it is by no means so.

Fig. 1.



Induction for Non-magnetic substances

Fig. 2.



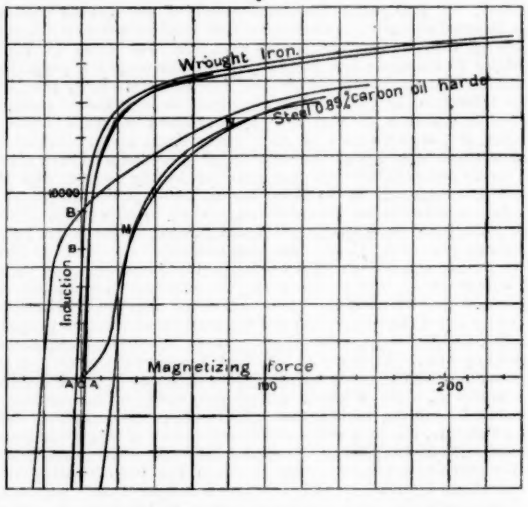
You will observe that the ordinates in these curves, which are proportional to the kicks or elongations of the galvanometer, are called induction, and that the abscissæ are called magnetising force. Let us see a little more precisely what we mean by the terms, and what are the units of measurement taken. The elongation of the galvanometer measures an impulsive electromotive force—an electromotive force acting for a very short time. Charge a condenser to a known potential, and discharge it through the galvanometer: the needle of the galvanometer will swing aside through a number of divisions proportional to the quantity of electricity in the condenser—that is, to the capacity and the potential. From this we may calculate the quantity of electricity required to give a unit elongation. Multiply this by the actual resistance of the secondary circuit and we have the impulsive electromotive force in volts and seconds, which will, in the particular secondary circuit, give a unit elongation. We must

multiply this by 10^8 to have it in absolute C.G.S. units. Now the induction is the impulsive electromotive force in absolute C.G.S. units divided by the number of secondary coils and by the area of section of the ring in square centimetres. The line integral of magnetising force is the current in the primary in absolute C.G.S. units — that is, one-tenth of the current in ampères—multiplied by 4π. The magnetising force is the line integral divided by the length of the line over which that line integral is distributed. This is, in truth, not exactly the same for all points of the section of the ring—an imperfection so far as it goes in the ring method of experiment. The absolute electromagnetic C.G.S. units have been so chosen that if the ring be perfectly non-magnetic the induction is equal to the magnetising force. We may refer later to the permeability, as Sir W. Thomson calls it; it is the ratio of the induction to the magnetising force causing it, and is usually denoted by μ.

There is a further difference between the limited class of magnetic bodies and the great class which are non-magnetic. To show this, we may suppose our experiment with the ring to be varied in one or other of two or three different ways. To fix our ideas, let us suppose that the secondary coil is collected in one part of the ring, which, provided that the number of turns in the secondary is maintained the same, will make no difference in the result in the galvanometer. Let us suppose, further, that the ring is divided so that its parts may be plucked from together, and the secondary coil entirely withdrawn from the ring. If now the primary current have a certain value, and if the ring be plucked apart and the secondary coil withdrawn, we shall find that, whatever be the substance of which the ring is composed, the galvanometer deflection is one-half of what it would have been if the primary current had been reversed. I should, perhaps, say approximately one-half, as it is not quite strictly the case in some samples of steel, although, broadly speaking, it is one-half. This is natural enough, for the exciting cause is reduced from—let us call it a positive value—to nothing when the secondary coil is withdrawn; it is changed from a positive value to an equal and opposite negative value when the primary current is reversed. Now comes the third characteristic difference between the magnetic bodies and the non-magnetic. Suppose that, instead of plucking the ring apart when the current had a certain value, the current was raised to this value and then gradually diminished to nothing, and that then the ring was plucked apart and the secondary coil withdrawn. If the ring be non-magnetic, we find that there is no deflection of the galvanometer; but, on the other hand, if the ring be of iron, we find a very large deflection, amounting, it may be, to 80 or 90 per cent. of the deflection caused by the withdrawal of the coil when the current had its full value. Whatever be the property that the passing of the primary current has imparted to the iron, it is clear that the iron retains a large part of this property after the current has ceased. We may push the experiment a stage further. Suppose that the current in the primary is raised to a great value, and is then slowly diminished to a smaller value, and that the ring is opened and the secondary coil withdrawn. With most substances we find that the galvanometer deflection is precisely the same as if the current had been simply raised to its final value. It is not so with iron: the galvanometer deflection depends not alone upon the current at the moment of withdrawal, but on the current to which the ring has been previously subjected. We may then draw another curve (fig. 2) representing the galvanometer deflections produced when the current has been raised to a high value and has been subsequently reduced to a value indicated by the abscissæ. This curve may be properly called a descending curve. In the case of ordinary bodies this curve is a straight line coincident with the straight line of the ascending curve, but for iron is a curve such as is represented in the drawing. You observe that this curve descends to nothing like zero when the current is reduced to zero; and that when the current is not only diminished to zero, but is reversed, the galvanometer deflection only becomes zero when the reversed current has a substantial value. This property possessed by magnetic bodies of retaining that which is impressed upon them by the primary current has been called by Prof. Ewing "hysteresis," or, as similar properties have been observed in quite other connections, "magnetic hysteresis." The name is a good one, and has been adopted. Broadly speaking, the induction as measured by the galvanometer deflection is independent of the time during which the successive currents have acted, and depends only upon their magnitude and order of succession. Some recent experiments of Prof. Ewing, however, seem to show a well-marked time effect. There are curious features in these experiments which require more elucidation.

It has been pointed out by Warburg, and subsequently by Ewing, that the area of curve 2 is a measure of the quantity of energy expended in changing the magnetism of the mass of iron from that produced by the current in one direction to that produced by the current in the opposite direction and back again. The energy expended with varying amplitude of magnetising forces has been determined for iron, and also for large magnetising forces for a considerable variety of samples of steel. Different sorts of iron and steel differ from each other very greatly in this respect. For example, the energy lost in a complete cycle of reversals in a sample of Whitworth's mild steel was about 10,000 ergs per cubic centimetre; in oil-hardened hard steel it was near 100,000; and in tungsten steel it was near 200,000—a range of variation of 20 to 1. It is, of course, of the greatest possible importance to keep this quantity low in the case of armatures of dynamos, and in that of the cores of transformers. If the armature of a dynamo machine be made of good iron, the loss from hysteresis may easily be less than 1 per cent.; if, however, to take an extreme case, it were made of tungsten steel, it would readily amount to 20 per cent. In the case of transformers and alternate-current dynamo machines, where the number of reversals per second is great, the loss of power by hysterisis of the iron, and the consequent heating, become very important. The loss of power by hysteresis increases more rapidly than does the induction. Hence it is not well in such machines to work the iron to anything like the same intensity of induction as is desirable in ordinary continuous current machines. The quantity, O A, when measured in proper units, as already explained—that is to say, the reversed magnetic force, which just suffices to reduce the induction as measured by the kick on the galvanometer to nothing after the material has been submitted to a very great magnetising force—is called the "coercive force," giving a definite meaning to a term which has long been used in a somewhat indefinite sense. The quantity is really the important one in judging the magnetism of short permanent magnets. The residual magnetism, O B, is then practically of no interest at all; the magnetic moment depends almost entirely upon the coercive force. The range of magnitude is somewhat greater than in the case of the energy dissipated in a complete reversal. For very soft iron the coercive force is 1·6 C.G.S.. units; for tungsten steel, the most suitable material for magnets, it is 51 in the same units. A very good guess may be made of the amount of coercive force in a sample of iron or steel by the form of the ascending curve, determined as I described at first. This is readily

Fig. 3.



seen by inspection of fig. 3, which shows the curves in the cases of wrought iron, and steel containing 0·9 per cent. of carbon. With the wrought iron a rapid ascent of the ascending curve is made, when the magnetising force is small and the coercive force is small; in the case of the hard steel the ascent of the curve is made with a larger magnetising current, and the coercive force is large. There is one curious feature shown in the curve for hard steel which may, so far as I know, be observed in all magnetisable substances: the ascending curve twice cuts the descending curve, as at M and N. This peculiarity was, so far as I know, first observed by Professor G. Wiedemann.

I have already called emphatic attention to the fact that magnetic substances are enormously magnetic, and that non-magnetic substances are hardly at all magnetic; there is between the two classes no intermediate class. The magnetic property of iron is exceedingly easily destroyed. If iron be alloyed with 12 per cent. of manganese, the kick on the galvanometer which the material will give, if made into a ring, is only about 25 per cent. greater than is the case with the most completely non-magnetic material, instead of being some hundreds of times as great, as would be the case with iron. Further, with this manganese steel, the kick on the galvanometer is strictly proportional to the magnetising current in the primary, and the material shows no sign of hysteresis. In short, all its properties would be fully accounted for if we supposed that manganese steel consisted of a perfectly non-magnetic material, with a small percentage of metallic iron mechanically admixed therewith. Thus the property of non-magnetisablity of manganese steel is an excellent proof of the fact—which is also shown by the non-magnetic properties of most compounds of iron—that the property appertains to the molecule, and not to the atom; or, to put it in another way, suppose that we were to imagine manganese steel broken up into small particles, as these particles became smaller there would at length arrive a point at which the iron and the manganese would be entirely separated from each other; when this point is reached the particles of iron are non-magnetic. By the magnetic molecule of the substance we mean the smallest part which has all the magnetic properties of the mass. The magnetic molecule must be big enough to contain its proportion of manganese. In iron, then, we must have a collection of particles of such magnitude that it would

be possible for the manganese to enter into each of them, to constitute an element of the magnet. Manganese is, so far as I know, a non-magnetic element. Smaller proportions of manganese reduce the magnetic property in a somewhat less degree, the reduction being greater as the quantity of manganese is greater. It appeared very possible that the non-magnetic property of manganese steel was due to the coercive force being very great—that, in fact, in all experiments we were still on that part of the magnetisation curve below the rapid rise, and that if the steel were submitted to greater forces it would presently prove to be magnetic, like other kinds of steel. Prof. Ewing, however, has submitted manganese steel to very great forces indeed, and finds that its magnetism is always proportional to the magnetising force.

No single body is known having the property of capacity for magnetism in a degree which is neither very great nor very small; but intermediate between the two extremes. We can, however, mix magnetic and non-magnetic substances to form bodies apparently intermediate. It is, therefore, interesting to consider what the properties might be of such a mixture. It depends quite as much on the way in which the magnetic part

Fig. 4.

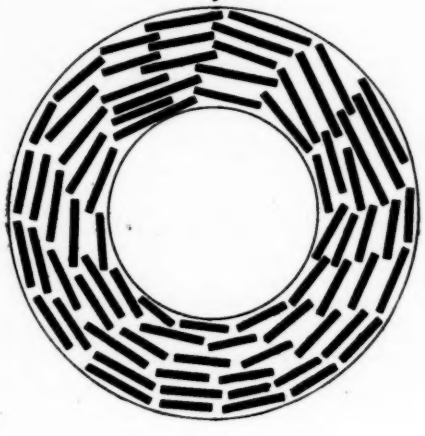


Fig. 5.

is arranged in the mass, as on its actual quantity. Suppose, for example, it is arranged as in fig. 4—in threads or plates having a very long axis in the direction of the magnetising force—we may at once determine the curve of magnetisation of the mixture from that of the magnetic substance by dividing the induction for any given force in the ratio of the whole volume to the volume of magnetic substance. If, on the other hand, it is as in fig. 5—with a very short axis in the direction of the force, and a long axis perpendicular thereto—we can equally construct the curve of magnetisation. This is done in fig. 6, which shows the curve when nine-tenths of the material is highly magnetic iron arranged as in fig. 5, whilst the other curve of the same figure is that when only one-tenth is magnetic, but arranged as in fig. 4. You observe how very different is the character of the curve—a difference which is reduced by the much less proportion of magnetic material in the mixture in the one case than in the other. One peculiarity of these arrangements of the two materials in relation to each other is, that the resulting material is not isotropic; that is, its properties are not the same in all directions, but depend upon the direction of the magnetising force in the material. Of course, this is not at all a probable arrangement, but it is instructive in showing the character of the result as depending upon the construction of the material. Let us, however, consider the simplest isotropic arrangement; let us suppose that one material is in the form of spheres bedded in a matrix of the other: if the spheres are placed at random this is clearly an isotropic arrangement. The result is very different according as the matrix or the spheres are of the magnetic material. Suppose that the volume of the spheres is one-half of the whole volume. In fig. 7 we have approximately the curve for iron, for a mixture of equal quantities of iron and a non-magnetic material; the spheres being non-magnetic and the matrix iron, and for a mixture, the spheres being iron, and the matrix non-magnetic. Observe the great difference. When the spheres are iron, the induction is near four times the force for all values of the force. When the matrix is iron, the induction is near $\frac{2}{3}$ths of the induction when the material is iron only.

In speaking of the properties of bodies which, like manganese steel, are slightly magnetic, it may be well here to enter a caution. But little that is instructive is to be learned by testing filings, or the like, with magnets, as these show but little difference between bodies which are slightly magnetic and those which are strongly magnetic. Suppose the filings to be spheres, in the following table are given comparative value of the forces they would experience in terms of μ, if placed in a magnetic field of given value, μ having its ordinary signification—that is, being the ratio of the kick on the galvanometer when a ring is tried

Fig. 6.

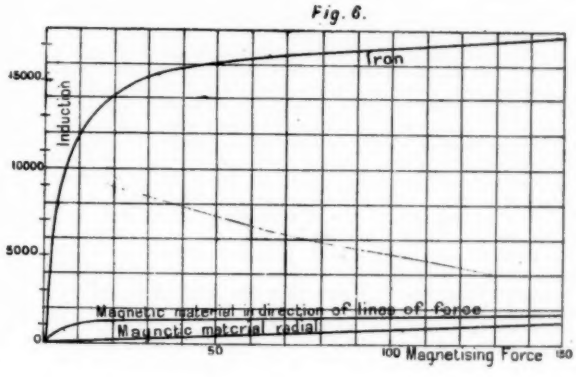
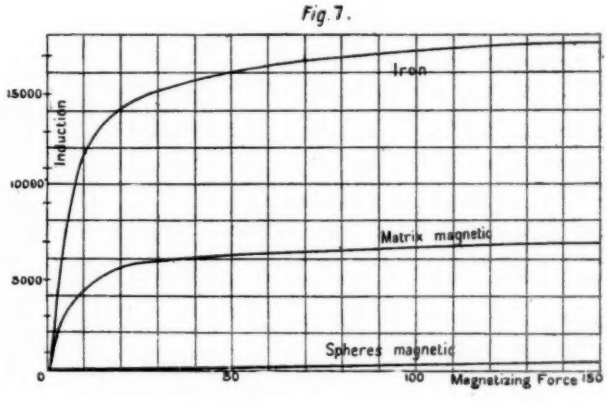


Fig. 7.



made of the material of the filing to the kick if the ring is made of a perfectly non-magnetic material:—

μ	Attraction.	
1	0	Non-magnetic body
1·47	0·18	Manganese steel with 12 per cent.
3·6	1·2	Manganese steel with 9 per cent.
5	1·5	
10	2·1	
100	2·8	
1,000	2·98	

Now, bodies in which μ is so small as 3·6 belong distinctly o ne non-magnetic class; but the test with the magnet would very markedly distinguish them from manganese steel with 12 per cent. of manganese. The distinction, however, between $\mu = 3{\cdot}6$ and $\mu = 1{,}000$ is comparatively small; whereas, under the conditions of experiment, μ is much more than 1,000 for most bodies of which iron is the principal constituent.

The effect of stress on the magnetic properties of iron and nickel have been studied by Sir W. Thomson. A fact interesting from a broad and general point of view is that the effects of stress are different in kind in the case of iron and nickel. In the case of iron, for small magnetising forces in the direction of the tension, tension increases the magnetisation; for large forces, diminishes it. In the case of nickel the effect is always to diminish the magnetisation.

When one considers that the magnetic property is peculiar to

three substances—that it is easily destroyed by the admixture of some foreign body, as manganese—one would naturally expect that its existence would depend also on the temperature of the body. This is found to be the case. It has long been known that iron remains magnetic to a red heat, and that then it somewhat suddenly ceases to be magnetic, and remains at a higher temperature non-magnetic. It has long been known that the same thing happens with cobalt, the temperature of change, however, being higher; and with nickel, the temperature being lower. The magnetic characteristics of iron at a high temperature are interesting. Let us return to our ring, and let us suppose that the coils are insulated with a refractory material, such as asbestos paper, and that the ring is made of the best soft iron. We are now in a position to heat the ring to a high temperature, and to experiment upon it at high temperatures in exactly the same way as before. The temperature can be approximately determined by the resistance of one of the copper coils. Suppose, first, that the current in the primary circuit which we use for magnetising the ring is small; that from time to time, as the ring is heated and the temperature rises, an experiment is made by reversing the current in the primary circuit and observing the deflection of the galvanometer needle. At the ordinary temperature of the air the deflection is comparatively small; as the temperature increases the deflection also increases, but slowly at first; when the temperature, however, reaches something like 600° C., the galvanometer deflection begins very rapidly to increase, until, with a temperature of 770° C., it attains a value of no less than 11,000 times as great as the deflection would be if the ring had been made of glass or copper, and the same exciting current had been used. Of course, a direct comparison of 11,000 to 1 cannot be made; to make it we must introduce resistance into the secondary circuit when the iron is used; and we must, in fact, make use of larger currents when copper is used. However, the ratio of the induction in the case of iron to that in the case of copper, at 770° C., for small forces is no less than 11,000 to 1. Now mark what happens. The temperature rises another 15° C.; the deflection of the needle suddenly drops to a value which we must regard as infinitesimal in comparison to that which it had at a temperature of 770° C.; in fact, at the higher temperature of 785° C. the deflection of the galvanometer with iron is to that with copper in a ratio not exceeding that of 1·14 to 1. Here, then, we have a most remarkable fact: at a temperature of 770° C. the magnetisation of iron 11,000 times as great as that of a non-magnetic substance; at a temperature of 785° C. iron practically non-magnetic. These changes are shown in fig. 8. Suppose now that the current in the primary circuit which serves to magnetise the iron had been great instead of very small. In this case we find a very different order of phenomena. As the temperature rises the deflection on the galvanometer diminishes very slowly till a high temperature is attained; then the rate of decrease is accelerated until, as the temperature at which the sudden change occurred for small forces is reached, the rate of diminution becomes very rapid indeed, until, finally, the magnetism of the iron disappears at the same time as for small forces. Instead of following the magnetisation with constant forces for varying temperatures, we may trace the curve of magnetisation for varying forces with any temperature we please. Such curves are given in diagrams 9 and 10. In the one diagram, for the purpose of bringing out different points in the curve, the scale of abscissæ is 20 times as great as in the other. You will observe that the effect of rise of temperature is to diminish the maximum magnetisation of which the body is capable, slowly at first, and rapidly at the end. It is also very greatly to diminish the coercive force, and to increase the facility with which the body is magnetised. To give an idea of the magnetising forces in question, the force for fig. 8 was 0·3; and as you see from figs. 9 and 10, the force ranges as high as 60. Now the earth's force in these latitudes is 0·43, and the horizontal component of the earth's force is 0·18. In the field of a dynamo machine the force is often more than 7,000. In addition to the general characteristics of the curve of magnetisation, a very interesting, and, as I take it, a very important, fact comes out. I have already stated that if the ring be submitted to a great current in one direction, which current is afterwards gradually reduced to zero, the ring is not in its non-magnetic condition, but that it is, in fact, strongly magnetised. Suppose now we heat the ring, whilst under the influence of a strong magnetising current, beyond the critical temperature at which it ceases to have any magnetic properties, and that then we reduce the current to zero, we may in this state try any experiment we please. Reversing the current on the ring, we shall find that it is in all cases non-magnetic. Suppose next that we allow the ring to cool without any current in the primary, when cold we find that the ring is magnetised; in fact, it has a distinct recollection of what had been done to it before it was heated to the temperature at which it ceased to be magnetic. When steel is tried in the same way with varying temperatures, a similar sequence of phenomena is observed; but for small forces the permeability rises to a lower maximum, and its rise is less rapid. The critical temperature at which magnetism disappears changes rapidly with the composition of the steel. For very soft charcoal iron wire the critical temperature is as high as 880° C.; for hard Whitworth steel it is 690° C.

The properties of an alloy of manganese and iron are curious. More curious are those of an alloy of nickel and iron. The alloy of nickel and iron containing 25 per cent. of nickel is non-magnetic as it is sure to come from the manufacturer; that is to say, a substance compounded of two magnetic bodies is non-magnetic. Cool it, however, a little below freezing, and its properties change: it becomes very decidedly magnetic. This is perhaps not so very remarkable: the nickel steel has a low critical temperature—lower than we have observed in any other magnetisable body. But if now the cooled material be allowed to return to the ordinary temperature it is magnetic; if it be heated it is still magnetic, and remains magnetic till a temperature of 580° C. is attained, when it very rapidly becomes non-magnetic, exactly as other magnetic bodies do when they pass their critical temperature. Now cool the alloy: it is non-magnetic, and remains non-magnetic till the temperature has fallen to below freezing. The history of the material is shown in fig. 11, from which it will be seen that from—20° C. to 580° C. this alloy may exist in either of two states, both quite stable—a magnetic and a non-magnetic—and that the state is determined by whether the alloy has been last cooled to —20° C. or heated to 580° C.

Sudden changes occur in other properties of iron at this very critical temperature at which its magnetism disappears. For example, take its electrical resistance. On the curve, fig. 12, is shown the electrical resistance of iron at various temperatures, and also, in blue, the electrical resistance of copper or other pure metal. Observe the difference. If the iron is heated its resistance increases with an accelerating velocity, until, when near the critical temperature, the rate of increase is five times as much as the copper; at the critical temperature the rate suddenly changes,

Fig. 8.

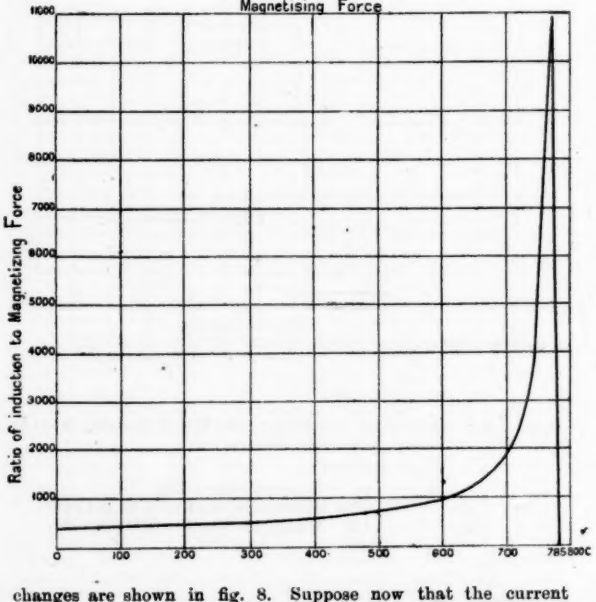


Fig. 9.

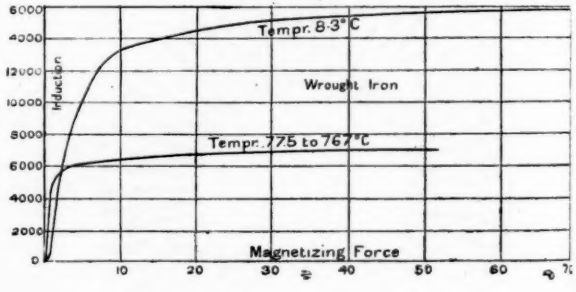
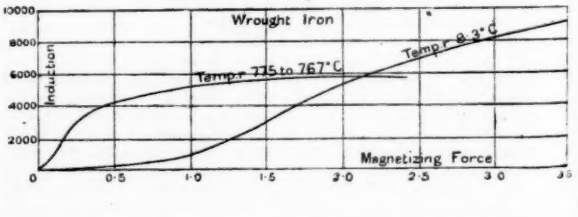
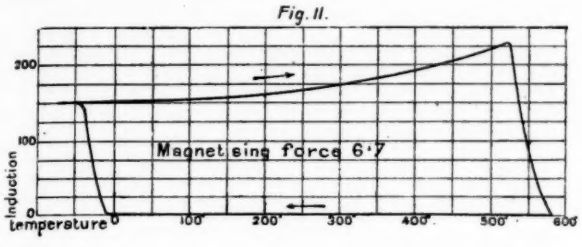


Fig 10.



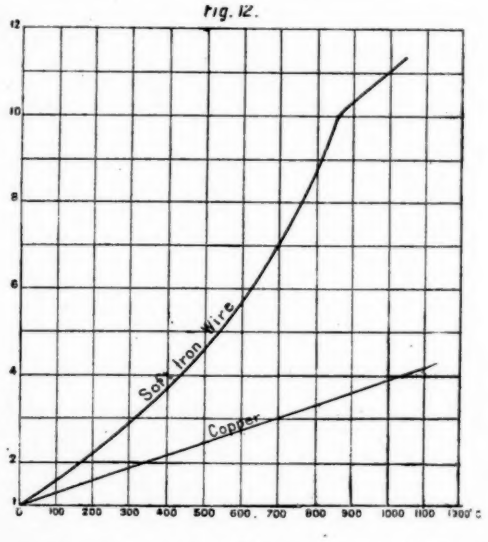
and it assumes a value which, as far as experiments have gone, cannot be said to differ very materially from a pure metal. The resistance of manganese steel shows no such change; its temperature coefficient constantly has the value of ·0012, which it has at the ordinary temperature of the air. The electrical resistance of nickel varies with temperature in an exactly similar manner. Again, Prof. Tait has shown that the thermo-electric properties of iron are very anomalous—that there is a sudden change at or about the temperature at which the metal becomes non-magnetic, and that before this temperature is reached the variations of thermo-electric property are quite different from a non-magnetic metal.

Fig. 11.



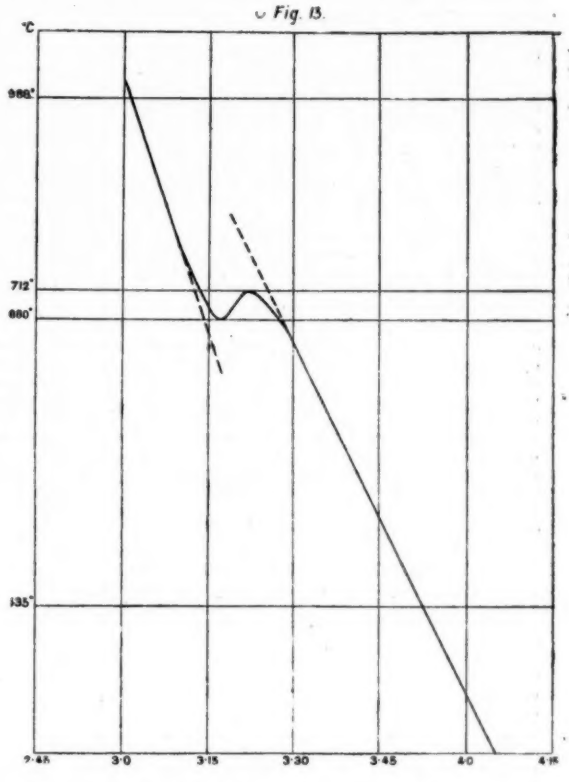
Prof. Tomlinson has investigated how many other properties of iron depend upon the temperature. But the most significant phenomenon is that indicated by the property of recalescence. Prof. Barrett, of Dublin, observed that if a wire of hard steel is heated to a very bright redness, and is then allowed to cool, the wire will cool down till it hardly emits any light at all, and that then it suddenly glows out quite bright again, and afterwards finally cools. This phenomenon is observed with great difficulty in the case of soft iron, and is not observed at all in the case of manganese steel. A fairly approximate numerical

Fig. 12.



measurement may be made in this way: Take a block of iron or steel on which a groove is cut, and in this groove wind a coil of copper wire insulated with asbestos; cover the coil with many layers of asbestos; and finally cover the whole lump of iron or steel with asbestos again. We have now a body which will heat and cool comparatively slowly, and which will lose its heat at a rate very approximately proportional to the difference of temperature between it and the surrounding air. Heat the block to a bright redness, and take it out of the fire and observe the resistance of the copper coil as the temperature falls, due to the cooling of the block. Plot a curve in which the abscissæ are the times, and the ordinates the logarithms, of the increase of resistance of the copper coil above its resistance at the temperature of the room. If the specific heat of the iron were constant, this curve would be a straight line; if at any particular temperature latent heat were liberated, the curve would be horizontal so long as the heat was being liberated. If now a block be made of manganese steel, it is found that the curve is very nearly a straight line, showing that there is no liberation of latent heat at any temperature. If it is made of nickel steel with 25 per cent. of nickel, in its non-magnetic state, the result is the same—no sign of liberation of heat. If now the block be made of hard steel, the temperature diminishes at first; then the curve (fig. 13) which represents the temperature bends round: the temperature actually rises many degrees whilst the body is losing heat. The liberation of heat being completed, the curve finally descends as a straight line. From inspection of this curve it is apparent why hard steel exhibits a sudden accession of brightness as it yields up its heat. In the case of soft iron the temperature does not actually rise as the body loses heat, but the curve remains horizontal, or nearly horizontal, for a considerable time. This, again, shows why, although a considerable amount of heat is liberated at a temperature corresponding to the horizontal part of the curve, no marked recalescence can be obtained. From curves such as these it is easy to calculate the amount of heat which becomes latent. As the iron passes the critical point it is found to be about 200 times as much heat as is required to raise the temperature of the iron 1°

Fig. 13.



Centigrade. From this we get a very good idea of the importance of the phenomenon. When ice is melted and becomes water, the heat absorbed is 80 times the heat required to raise the temperature of the water 1° Centigrade, and 160 times the heat required to raise the temperature of the ice by the same amount. The temperature of recalescence has been abundantly identified with the critical temperature of magnetism.* I am not aware that anything corresponding with recalescence has been observed in the case of nickel. Experiments have been tried, and gave a negative result, but the sample was impure; and the result may, I think, be distrusted as an indication of what it would be in the case of pure nickel. The most probable explanation in the case of iron, at all events, appears to be that when iron passes from the magnetic to the non-magnetic state it experiences a change of state of comparable importance with the change from the solid to the liquid state, and that a large quantity of heat is absorbed in the change. There is, then, no need to suppose chemical change; the great physical fact accompanying the absorption of heat is the disappearance of the capacity for magnetisation.

What explanations have been offered of the phenomena of magnetism? That the explanation must be molecular was early apparent. Poisson's hypothesis was that each molecule of a magnet contained two magnetic fluids, which were separated from each other under the influence of magnetic force. His theory explained

*I have only recently become acquainted with the admirable work of M. Osmond on recalescence. He has examined a great variety of samples of steel, and determined the temperatures at which they give off an exceptional amount of heat. Some of his results are apparent on my own curves, though I had assumed them to be mere errors of observation. For example, referring to my Royal Society paper, there is, in fig. 38, a hint of a second small anomalous point a little below the larger one. And, comparing figs. 38 and 38A, we see that the higher the heating the lower is the point of recalescence; both features are brought out by M. Osmond. The double recalescence observed by M. Osmond in steel, with a moderate quantity of carbon, I would explain provisionally by supposing this steel to be a mixture of two kinds which have different critical temperatures. Although M. Osmond's method is admirable for determining the temperature of recalescence, and whether it is a single point or multiple, it is not adapted to determine the quantity of heat liberated, as the small sample used is enclosed in a tube of considerable mass, which cools down at the same time as the sample experimented upon.

the fact of magnetism induced by proximity to magnets, but beyond this it could not go. It gave no hint that there was a limit to the magnetisation of iron—a point of saturation; none of hysteresis; no hint of any connection between the magnetism of iron and any other property of the substance; no hint why magnetism disappears at a high temperature. It does, however, give more than a hint that the permeability of iron could not exceed a limit much less than its actual value, and that it should be constant for the material, and independent of the force applied. Poisson gave his theory a beautiful mathematical development, still useful in magnetism and in electrostatics.

Weber's theory is a very distinct advance on Poisson's. He supposed that each molecule of iron was a magnet with axes arranged at random in the body; that under the influence of magnetising force the axes of the little magnets were directed to parallelism in a greater degree as the force was greater. Weber's theory thoroughly explains the limiting value of magnetisation, since nothing more can be done than to direct all the molecular axes in the same direction. As modified by Maxwell, or with some similar modification, it gives an account of hysteresis, and of the general form of the ascending curve of magnetisation. It is also very convenient for stating some of the facts. For example, what we know regarding the effect of temperature may be expressed by saying that the magnetic moment of the molecule diminishes as the temperature rises, hence that the limiting moment of a magnet will also diminish; but that the facility with which the molecules follow the magnetising force is also increased, hence the great increase of μ for small forces, and its almost instantaneous extinction as the temperature rises. Again, in terms of Weber's theory, we can state that rise of temperature enough to render iron non-magnetic will not clear it of residual magnetism. The axis of the molecules are brought to parallelism by the force which is impressed before and during the time that the magnetic property is disappearing; they remain parallel when the force ceases, though, being now non-magnetic, their effect is nil. When, the temperature falling, they become again magnetic, the effect of the direction of their axes is apparent. But Weber's theory does not touch the root of the matter by connecting the magnetic property with any other property of iron, nor does it give any hint as to why the moment of the molecule disappears so rapidly at a certain temperature.

Ampère's theory may be said to be a development of Weber's: it purports to state in what the magnetism of the molecule consists. Associated with each molecule is a closed electric current in a circuit of no resistance; each such molecule, with its current, constitutes Weber's magnetic molecule, and all that it can do they can do. But the great merit of the theory—and a very great one it is—is that it brings magnetism in as a branch of electricity; it explains why a current makes a magnetisable body magnetic. It also gives, as extended by Weber, an explanation of diamagnetism. It, however, gives no hint of connecting the magnetic properties of iron with any other property. Another difficulty is this: When iron ceases to be magnetisable, we must assume that the molecular currents cease. These currents represent energy. We should therefore expect that, when iron ceased to be magnetic by rise of temperature, heat would be liberated; the reverse is the fact.

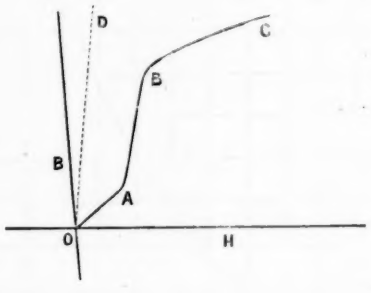
So far as I know, nothing that has ever been proposed even attempts to explain the fundamental anomaly, Why do iron nickel, and cobalt possess a property which we have found nowhere else in nature? It may be that at lower temperatures other metals would be magnetic, but of this we have at present no indication. It may be that, as has been found to be the case with the permanent gases, we only require a greater degree of cold to extend the rule to cover the exception. For the present, the magnetic properties of iron, nickel, and cobalt stand as exceptional as a breach of that continuity which we are in the habit of regarding as a well-proved law of nature.

DISCUSSION.

(Authorised Abstract)

Sir WILLIAM THOMSON said the President had done well to emphasise the marvellous properties of iron, nickel and cobalt, but he thought these properties were not quite so much isolated as would appear from the address. Faraday showed the continuity between paramagnetic and diamagnatic bodies, and that all substances are susceptible to magnetism when subjected to sufficiently intense magnetising forces. He had also compared the relative susceptibilities of materials such as glass, bismuth, wood, &c.; but the absolute determination of their susceptibilities still presents a large field for interesting and valuable research. The fact that the magnetic properties of such substances could be compared was itself of immense importance, whilst Tyndall's observations on the properties of bread, Iceland spar, &c., which can be made, or are naturally magnetically anisotropic, further enhances the interest connected with the subject. The prodigious difference between the magnetic properties of iron, nickel and cobalt, and those of other substances, the speaker considered to be one of the great marvels of nature, and many ideas had been suggested by the President's address, which so forcibly emphasised these great distinctions. Referring to the absence of deflection of the ballistic galvanometer when a copper core is withdrawn from a coil, he said this does not prove that no effect takes place in the copper during the process, for in reality two equal and opposite effects occur in rapid succession, thus neutralising each other's influence on the slow moving needle. In iron, however, in addition to these induced currents in the metal itself, a change in the induced magnetism makes itself evident by a throw of the needle. The fact that a current or magnet when placed near iron exerts a permanent influence on the iron, whereas no such effect is produced on copper or non-magnetic bodies, always seemed to him a marvellous difference. As regards the President's remark that Poisson's theory gave no hint of hysteresis, this he thought was open to question, for the theory refers to coercive force, and this is hysteresis under another name. Coming to the subject of recalescence, Sir William said this was of immense importance, and one of the wonders duly accentuated by the President. In this connection he wished to add that most of the work on the latent heat of iron about the temperature at which recalescence occurs, had been done by the President himself. The region about the ripple in fig. 13 requires further investigation and, if possible, a cycle such as Andrews used in his experiments on evaporation and condensation, should be devised. The material exists in two or more different states at the same temperature, and if the effect is reversible, then the iron should cool whilst heat is being supplied to it. In conclusion, Sir William suggested that several physical properties of the material should be tested statically whilst it was kept at temperatures little above and little below the critical one, and also during the various states in which the material exists at the same temperature.

Prof. EWING said he was glad to congratulate the society on being favoured with such a valuable address, for he was sure that it had been no less interesting to those little acquainted with the subject than to those familiar with recent researches. He, himself, was particularly interested in the matter, and was surprised that all the facts relating to magnetisation had been so clearly stated without using the word "susceptibility" or the expression "intensity of magnetisation." Commenting on the enormous amount of hysteresis exhibited by the alloy of nickel and iron (fig. 11), Prof. Ewing said he had looked for hysteresis in similar alloys, and found none; now he saw why he found none, for his experiments were made between ordinary atmospheric temperatures and 212° F., whilst Dr. Hopkinson, by increasing the range of temperature, had passed the critical points, and shown the hysteresis to be very great. One other point he wished to mention in connection with a probable instability which exists when iron is subjected



to small magnetising forces. Take the ordinary curve of magnetisation, this may be divided into three portions, O A. A B, B C (see fig). The part, O A, had been shown by Lord Rayleigh to be a straight line, and he (the speaker) found that in a true magnetisation curve, where the condition of endlessness was perfectly satisfied, the part, A B, should be vertical, or nearly so. His own experiments were made on rods from 300 to 400 diameters long, and on treating these mathematically as ellipsoids, he found that the magnetising force, H, should be measured from a line, O D, which is practically parallel to A B. A similar result had quite recently been obtained by Mr. Nagaroka, who, in some experiments on the magnetisation of nickel when subjected to mechanical stresses, had succeeded in lengthening the part, O A, considerably, and then found A B to be practically vertical. In his own (Prof. Ewing's) experiments on iron, he found that by tapping a rod whilst subjected to magnetising force, a permeability of 20,000 could be obtained.

The discussion was adjourned until the 23rd inst.

New York City Management.—In the fever of the recent panic, the New York City authorities appear to have gone merrily about cutting down wires and poles, without pausing to consider whether the wires were safe or dangerous. Naturally a reaction is setting in. The *New York Times*, erst one of the chief advocates of wholesale destruction, is now asking if anything is going to be done in the way of construction, "or are we to sit in darkness and admit that electric lighting is a failure?" The authorities, our contemporary adds, are "tearing down as if doomsday were near, and we were never more to have occasion for lighted streets." It is said 472,692 ft. of wires, and 338 poles have been removed.

COMMUNICATIONS FROM AUSTRIA-HUNGARY.

(FROM A CORRESPONDENT.)

I, some time ago, informed you that the water-power existing near the celebrated Austrian watering-place Gastein, was about to be utilised for the manufacture of aluminium. This project is now actually being brought into execution, and yesterday (January 8th), under the auspices of the Vienna "Landerbank," there took place a congress of Berlin, Frankfort and Swiss firms, for the installation of the aluminium works at Leyd-Gastein. The production will take place electrically as is the case at Neuhaus, in Switzerland, which works belong to the same syndicate, and have been for some time in operation. For working the electrical machines, 6,000 horse-power are available from the "Gasteiner-Ache" (name of a stream). Austrian capitalists participate to the extent of three-tenths and German firms to seven-tenths.

The telephonic connection between Vienna and Prague has been interrupted in consequence of the heavy glaciation of the wires, which were coated with ice to the thickness of a man's arm. It appears that the copper wires as well as the bronze arms of the telephone lines are not strong enough to bear the results of the weather. Hence the arrangement has been made to substitute arms of steel, and stronger wires are being put up. As this is the first winter which the Vienna-Prague telephone line has had to encounter, accurate observations are being made by the Ministry of Commerce, as to the means of avoiding such disturbances in future.

The intercommunication on the line from Vienna to Buda-Pest—just opened—is being slowly developed. The line is used by about 80 persons daily. This relatively slight demand is ascribed to the circumstance that the connection between the parties is now somewhat tedious, as the correspondent has first to receive notice telegraphically or telephonically (if practicable). As soon as the subscribers of the two telephonic nets are brought into direct communication with each other the intercommunication will doubtless increase.

At a meeting of the Austrian Meteorological Society Dr. Pernter communicated some interesting observations made on the "Sonnblick" (3,000 metres in height). The assistant, Peter Lechner, is now passing his third winter there as observer. At the suggestion of Dr. Pernter he has made five daily observations of the electric noises in his telephone, and for 20 months he has registered them on a scale where 0 stands for absolute silence and the strongest rattling as 5. It appears that in winter the telephonic noise decreases from morning to noon, and then rises in the night to a high maximum. In summer there is a constant increase from morning to night. In spite of many investigations Dr. Pernter has not been able to find any explanation of this periodicity. Its solution remains an interesting problem.

As regards the account (which you have reproduced) of the vertical tramline about to be undertaken by the Buda-Pest Tram Company conjointly with the firm Ganz & Co., on the system which you have described, I have to inform you that the Municipality has given its consent for the construction of a short trial line on this plan.

The Electric Lighting of Bridlington.—The inhabitants of Bridlington Quay are seriously considering the advisability of adopting the new light. It appears that the present gas supply is extremely unsatisfactory. It was publicly stated on a recent occasion that the Local Board could only light the town on an average 3¼ hours per night, and that the lighting had to be partially discontinued in the summer in order to afford a scarcely adequate supply during the winter. It was also stated that the town could be lighted by electricity for £900, or £100 more than it now pays for gas.

NOTES.

Electric Light in Bradford. — At the monthly meeting of the Bradford Town Council, held on Tuesday last, authority was given to expend a further sum of £10,000 upon electricity works. When the Corporation opened its central station in September last the demand only amounted to a current of 330 ampères. The demand has increased very rapidly since then, and 1,520 ampères are now being supplied. This is as much as the existing plant is capable of producing, and the additional vote is required for the purpose of providing more apparatus. Mr. Sydney Baynes has been appointed managing engineer for the electric lighting works.

St. Luke's Vestry and the Light.—At a recent meeting of the Vestry a letter was read from the Metropolitan Electric Supply Company, Limited, stating that it is not their intention to proceed with their proposed application to the Board of Trade for a provisional order.

Hove and the Electric Light.—The Electric Light Sub-Committee has been strengthened, and empowered to oppose as it thinks fit the application of the Brighton and Hove Electric Light Company for a provisional order.

Hornsey and the Electric Light.—At the last meeting of the Hornsey Local Board of Health there was a general consensus of opinion that the Board should not grant to any company exclusive powers in the district. The Board considers it can do the lighting itself with the surplus power at the new sanitary depôt.

Electric Lighting of Beverley.—The Town Council of Beverley recently considered the question of the electric lighting of that borough and the advisability of the Corporation undertaking the work.

The Electric Lighting of the Strand.—At the last meeting of the Strand Board of Works a discussion took place on the imperfect lighting of Covent Garden and the neighbourhood, and several additional lamps were ordered. Some disappointment was expressed at the delay in the electric lighting of the Strand; this, it is understood, cannot now be taken in hand until after the London season. The work of providing the light for the whole district will, the surveyor thinks, be completed in 18 months.

Marylebone Lighting.—At a recent meeting of the vestry it was agreed that notice should be given to the Metropolitan Electric Light Supply Company that where vaults exist under the footway pavements of any of the streets of the parish, the mains of the company shall be laid only in the roadway of such streets; and, further, that the company be made to deposit a sum of 2s. in footway and 3s. in roadway per lineal yard wherever commencing operations.

The Electric Lighting of Newcastle.—The Newcastle and District Electric Lighting Company commenced operations on the 10th, the first premises to receive the new light being the Douglas Hotel, Messrs. Handysides, and the London Supply Stores. In the course of a few days the Crown and Alexandra Hotels will be similarly lighted. The effect of the new luminant as compared with the gas light in the adjoining premises is said to have elicited the approval of all who witnessed it. It is calculated that the saving by its use in decoration and painting will be very considerable. The proprietors of the Tyne Theatre propose placing a very large and powerful light on the top of the building, which will light up the whole of the neighbourhood; and the owners of many large buildings in the town have signified their intention of adopting the new light.

The Cheapness of the Electric Light.—Mr. E. P. Philpots, of Bourne Hall, Bournemouth, who was one of the pioneers of the electric light in that town, has recently given his experiences with regard to the value of that illuminant. He says: "As a large consumer, by producing it myself, I find it cheaper than gas, as the steam, which drives my engine, pumps up water from my well, heats the house, and assists in cooking. Amongst other advantages arising from its use, I may mention that I save £60 a year in decoration, the air in the house is kept purer, and in my dining room, where daily upwards of 100 sat down at one time during last week, the temperature during a meal never rose more than three degrees. My regret now is that I had not the courage to use it in my bed rooms, instead of only lighting the public rooms and corridors with it. I trust that the public will support the Brush Company by universally adoping it, because, apart from its excellence and convenience, the greater the consumption of (or of any commodity), the cheaper its production becomes."

The Electric Lighting of London.—The Electricity Supply Corporation has abandoned its proposed order for powers to light the parish of Paddington, thus leaving the order deposited by the House-to-House Electric Supply Company unopposed, so far as the Corporation is concerned. The Corporation has also abandoned its proposed order for the lighting of the districts of St. Giles and the Strand Board of Works respectively.

Electricity Through Gas Mains.—At a recent meeting of the Manchester Association of Engineers the president, Mr. John West, said that in practice he thought the most economical and satisfactory way of producing and supplying electricity to the consumers would be by gas engines on their own premises, or a system of very small central stations where a few houses or shops in close proximity could be worked by the direct system of distribution. At the present time they had in Manchester excellent distributing plant for the purpose in the existing gas mains, which, by the aid of gas engines (which could be placed in a cellar, outbuilding, or any other position), would supply a power available at any time, requiring no constant attention and causing no smoke nuisance. Gas engines were already extensively used, Messrs. Crossley Brothers having sold 550 for that purpose. So, as far as he could judge, gas must remain by far the more economical of the two methods of lighting.

Orders Abandoned.—The National Electric Supply Company has decided not to proceed with its application to the Board of Trade for the electric lighting of Barnsley and Kingston-on-Hull.

New Work on Electricity.—M. E. Hospitalier has begun the publication of a work in two volumes, entitled "Traité Elementaire de l'Energie Electrique." The first volume, comprising the definition, principles, and general laws, has been issued. Vol. II., on industrial appliances, will be issued during the present year.

The Stanley Electric Medical Battery.—This battery is simply a new arrangement of the common Faradic or induction machine, and consists of a sulphate of mercury galvanic cell and an induction coil with its rheotome, contained in a cylindrical metallic case; this case serving as a convenient handle to a pad, which is attached to one end, while the metallic case, a handle itself, serves as the other electrode. At the end of the metallic handle, opposite the pad electrode, is the cell chamber, which is accessible by means of a vulcanite covered screw cap. The whole arrangement is one of the neatest we have ever come across, the form of the battery being extremely simple and effective, in fact as much an improvement on older forms of so-called pocket batteries as the modern stylograph is upon the old form of fountain pen.

Personal.—Mr. H. W. Edlin, M.Inst.M.E., has been compelled, through ill-health, to resign his appointment as the London representative of Messrs. Lacombe & Co. (the well-known carbon manufacturers), and is sailing for South Africa, where he intends to establish himself in business as electrical engineer and contractor. Mr. Edlin carried out the installations in the Palace of the King Roumania, the Prudential Assurance Company, the Bank of New Zealand, &c. We trust that he may speedily regain his health in the fine climate of the Cape, and we wish him every success.

Storms in the North.—A correspondent of the *Scotsman* wrote on the 11th:—There has been no communication with the Ben Nevis Observatory since Saturday night, the line having been damaged by the lightning on Sunday evening. The lineman from here attempted the ascent on Tuesday, but had to return before reaching the lake owing to the gale which was blowing. Yesterday he made the ascent, and found them all well, but could not return, as the evening was very stormy and dark. He has, however, returned this afternoon, having left them all well. It appears that a flash of lightning entered by the wire and struck the instrument first, then rolled on the floor like a ball, and burst under the table, making a loud report. Mr. Miller, who was sitting at the table, got a severe shock, but was not injured in any way. The flash illuminated the house, so much so that they were greatly alarmed for the moment.

Sending in the Bill.—It is reported that the electric lighting companies intend to sue the City of New York for three million dollars, the cost of the damage which they estimate has been done to their property during the recent overhead wire campaign.

A New Dynamo.—The new dynamo of the United States Electric Lighting Company has, says *Science*, had the benefit of many years of development. The patterns for it have recently been entirely remodelled to take advantage of the best points in the antecedent dynamos of both the Westinghouse and the United States Companies, and it is, consequently, a most practical and efficient generator. The field magnets part along a horizontal plane, so that by removing the yoke and unbolting the two halves the upper half can be lifted away and the armature removed. This is convenient in cramped situations. The same construction enables it to be carried on to restricted locations which would not be accessible to a dynamo built in one piece. The armature itself is wound in a single layer upon a laminated core, practically obviating the liability to heating. Ball bearings are used on both ends of the shaft. The lower horn of the casting is hollow and serves as a reservoir for oil running through the bearings. Oil can, therefore, be supplied copiously, and drawn off and returned to the cups without waste. The dynamo is carried on an elevated base, making it more accessible to the operator. If desired the legs may be removed and the base bolted to a foundation. The base is provided with the usual tension screw.

Electric Cars in Cleveland.—It is just a year since the first electric motor car run by the overhead system made its six miles trial trip in 40 minutes, being a saving in time over horse cars of 20 minutes. The East Cleveland Company has now 40 electric motors in service, all of them of twice the horse-power originally used. The cars are running 5,000 miles daily and reducing the duration of each trip by at least one-fifth as compared with horse-power a year ago, and affording 33 per cent. more seating room. The company has erected wires over 32 miles of track. The Brooklyn Company is running 30 motor cars over 24 miles of track, or 3,000 miles daily, at an average saving per trip of 20 per cent. The Broadway line has 12 miles of track and 8 motors running 1,000 miles daily, and saving 20 per cent. in time, with a doubled carrying capacity.

Gas v. the Electric Light.—The directors of the St. Austell Gas Company are playing into the hands of the proprietors of the electric light works, and already several large consumers have intimated their intention to cut off altogether the supply of gas to their premises. For many years the price of gas, per 1,000 ft., has been 4s. 6d., but now, owing, so the directors say, to the increased price of coal they are compelled to raise the price 6d. per 1,000 ft., thus making the charge 5s. One thing, however, is satisfactory to the large shopkeepers in the front street, that the electric light is now permanent, and that at a less cost they can have a better and less disagreeable light than that supplied by the gas company. The directors are, however, so considerate that they notify that in the event of any reduction in the price of coal, they would be only too happy to again reduce the price of gas, but in the opinion of many the price of coal is more likely to go up than down. The directors of Falmouth Gas Company have advanced the price of gas from 3s. 9d. to 4s. 3d. per 1,000 ft., owing to the increased price of coal, after paying 10 per cent. and a bonus for some time past. Is it not quite time that they had an electric light company to compete with?

Electric Light at Redruth.—We are pleased to find that the electric light has reached so far West as Redruth, where a gentleman has won the distinction of introducing it into that town in the form of a private installation. On Friday last, through the courtesy of the owner, Mr. R. H. Mitchell, a correspondent had the privilege of viewing it. Mr. Mitchell is a retired marine engineer of great repute, but, until the last two years, he had not taken up electrical work. At present his installation consists of a large Manchester dynamo, belt driven from a high-speed vertical steam engine and boiler, by Hampsted & Co., Grantham, which charges upwards of 30 large E.P.S. accumulators; but additions are being made in the form of extra boiler power, larger dynamo, and more cells. The accumulators, dynamo, engine, &c., are placed in a spacious outhouse at the end of the garden adjoining the house, so that the noise does not disturb the inmates. The cables are run overhead through specially-made insulators, designed by the owner, who has also devised a very good pattern mouthpiece to receive the cable on going through the walls. In the dynamo room was a well-designed switchboard, with ammeter and voltmeter, numerous switches, cut-outs, resistance coils, &c., and not the least interesting and important was a magnetic cut-out on the charging circuit, devised and constructed by Mr. Mitchell himself, on an entirely new principle, which, we are told, works admirably. The house is fitted throughout with incandescent lamps, some of them being of particular interest, having been purchased by Mr. Mitchell, of Mr. Swan himself, at a Paris Exhibition of years gone by. These had been overlooked until last year, when he commenced the work. The wiring, fitting, and general arrangement of the installation, from its conception to completion, has been the sole work of the owner, another example of the mechanical engineer turning to electrical matters with immediate and complete success.

Electric Lighting Wires at Exeter.—The question of electric lighting wires has assumed a somewhat acute phase at Exeter where at the last meeting of the corporation a resolution was moved, that in view of the report presented by the surveyor and fire superintendent, the Electric Lighting Company be informed that the further extension of the overhead wires will not be permitted. A member remarked that there was a feeling in the city that the council had acted without sufficient consideration in giving its permission. It was pointed out by another speaker that in Taunton not the slightest accident had occurred, although the overhead wires had been in existence there for four years. After considerable discussion the motion was rejected.

Competent Electrical Engineers Wanted.—The New York *Electrical Review* says there is already a dearth of competent electrical engineers, and that the manner in which the various cities are appointing electrical commissions and electrical experts to supervise plants and wires, only threatens to intensify the scarcity. It is most devoutly to be hoped, says our contemporary, that in these cases a good selection will be made, as the duties attached to the position of city electrician are now-a-days often new and decidedly onerous.

This Abominable Gas!—At the last fortnightly meeting of the Commissioners of Sewers a resolution was read from the vestry of St. Mary-le-Bow in opposition to the Central London Railway scheme. The Clerk having submitted applications from the London Electric Supply Corporation and the Metropolitan Electric Supply Company, for the Commissioners' consent to their applications for provisional orders under the Electric Lighting Acts, Mr. Rose Innes, jun., moved that the applications do lie on the table. He said that the Commissioners had already settled the matter so far as the Anglo-Brush Company was concerned, and they had given them a contract to carry out the electric lighting on the terms arranged by the Streets Committee. It would be most unfair to the contracting company if they agreed to these fresh applications seeking Parliamentary powers over the City. The Commissioners must be masters in their own place. They had quite enough Parliamentary powers over the City with the Gas and Water Committees. Mr. Deputy Scott said there would be an uproar if one portion of the city were lighted by electricity and the other not, and he moved an amendment that the Brush Company be approached with a view to its contracting for another portion of the City. People, he said, were asking, "When can we get rid of this abominable gas?" The amendment was eventually rejected, and Mr. Innes's motion carried unanimously.

A New Use for Electricity.—Electricity promises to become an important factor in deep seam coal mining. *The Engineer*, basing its opinion on both American and English experience, computes that the cost of the electrical plant will be something like 75 per cent. of that of compressed air plants of similar effective power, whilst, our contemporary adds, they will give something like double the efficiency. Having regard to the ease with which energy can be conducted by the copper conductors into parts now inaccessible except to hand and horse labour, our contemporary thinks it not improbable that in some colliery centres, where a number of pits is worked within a comparatively small area, large power stations will be erected on similar lines to the central lighting stations, and from them power distributed to motors below ground. The cables in many cases will be run on the surface and carried below through special bore holes of small diameter, by which means the cost of insulation would be much reduced. Assuming that such machines are used in non-gaseous seams, the cost of coal, *The Engineer* thinks, should be very considerably reduced.

Tenders Wanted for the Lighting of Florence.—The Municipality of Florence is prepared to grant a concession for 40 years for the lighting of the city by electricity. Tenders must be sent by Feb. 15.

William Sturgeon.—The following letter has just come to hand:—"Will you kindly permit me to enquire through your columns whether any one of your readers is cognisant of the existence of any portrait of William Sturgeon, the inventor of the electro-magnet, who died in 1850. He was long resident at Woolwich, lectured on electricity at the Adelaide Gallery and other places in London, and afterwards removed to Manchester. He founded the short-lived Electrical Society of London, and was the editor of the *Annals of Electricity*. Any personal information respecting him or his writings would be very gratefully received by Silvanus P. Thompson."

The Electrical Engineering Corporation, Limited.—An amalgamation has been arranged between Messrs. J. G. Statter and Co., Limited, and the United Electrical Engineering Company, Limited. It has been well known to the electrical profession that the latter company has acted as the London agents for Messrs. J. G. Statter & Co., Limited, during the past year, and with the now daily increasing volume of business it has been felt by the managing directors of the two companies that there existed a special fitness for amalgamation. The corporation is thus a manufacturing and supply undertaking, having exceptional facilities for co-operating with contractors and others in carrying out work at home and abroad in all branches of the electrical industries. The Alliance Engineering Works are favourably situated within 15 miles of London, on the main line of the Great Western Railway, and have a dock and wharf upon the Grand Junction Canal. The works are already extensive and complete, and when the extensions, now in progress, have been carried out, they will cover about four acres of ground, and contain some of the largest machine tools employed in the trade. The Albert Works on the Albert Embankment are devoted to the manufacture of switch, safety junction and regulator gear, together with other fittings and accessories suitable for a wide range of electrical work. The managing directors of the corporation are Messrs. J. G. Statter, Edward Manville, and Wm. L. Madgen. We may add that engines are built by the company, the extended works allowing it to turn out much larger plant than formerly.

Appointment.—Mr. F. Hollins, for many years the able assistant to Mr. Langdon, telegraph superintendent nad electrical engineer to the Midland Railway Company, has received the appointment of telegraph superintendent and electrical engineer to the Great Eastern Railway Company, at a salary of £500 per annum. Mr. Hollins entered upon his new duties on the 13th instant. He has, we believe, given a great deal of attention to the subject of train lighting by electricity.

St. George's Vestry to the Rescue.—The St. George's (Hanover Square) Vestry is up in arms against the London Subway Railway scheme. At a recent meeting the Electric Lighting Committee recommended the vestry to petition against the Bill, and an amendment that it should be opposed by counsel was finally adopted. In the course of the discussion it was stated that the railway, if carried out, would depreciate the property in the neighbourhood of Oxford Street 20 per cent.

Fowler, Lancaster and Company.—This firm, which has been registered very recently as a limited liability company, has already issued its first catalogue of electrical and telegraphic apparatus, bells, batteries, and instruments. Prices have been revised, and, in some instances, reduced. The works of the company being in the centre of the metal markets, and well adapted for the manufacture of electrical appliances of all kinds, the prospect of doing a largely increased business in the future is a very cheerful one. Messrs. Fowler, Lancaster and Company received awards at both the Paris and the Birmingham exhibitions of 1889 for their electrical specialities.

Ransomes, Sims and Jefferies.—This company has just issued a new edition of its catalogue of engines, boilers and mining machinery, including engines specially designed for electric light installations and fitted with patent automatic governor expansion gear.

The Telegraph System in India.—According to the *Pioneer* (Allahabad), the advisability of putting the Indo-European and Indian telegraph systems under separate heads, is once more under consideration.

Atlantic Cables.—The s.s. *Faraday* has arrived after successfully laying two cables from Nova Scotia to new York for the Western Union Telegraph Company, and repairing the fracture in one of the main Atlantic cables. The latter task was performed on the last day of 1889 in stormy weather.

Action by an Electrical Engineer.—At the Torquay County Court, on Saturday, Mr. Radcliffe, an electrical engineer, sued the Great Western Railway Company to recover 10s. damage alleged to have been done to an incandescent lamp in transit for London. It appeared that the lamp was enclosed in a case marked "Glass, with great care," but on its receipt the carbon inside was found to be broken. His Honour said he could not see how this label would apply, as the glass globe was not broken. It seemed curious to him how the carbon became broken without the glass. Plaintiff said it was quite possible for this to happen if the box was let fall suddenly. Mr. Rullen, station-master at Torre Station, said that the defendant company did not dispute the damage, but fought the case on principle. They wished for an adjournment, which was agreed to on the understanding that defendants were to pay the costs of the day.

Telephone and Electric Lighting Wires.—In Bamberg, Bavaria, the telephone and electric lighting wires do not get on at all well together; so much so that during the hours of lighting the telephone service between that place and Nuremberg comes to a standstill. An official investigation has brought to light that the so-called induction is transmitted by the earth, and largely, by means of the water mains.

Electric Doors in a Theatre.—The theatre at Tremont, New England, is fitted with electric doors, which can be opened by simply touching one of eight push buttons, situated in convenient places. On the slightest alarm, 17 sets of folding doors are immediately and simultaneously thrown open by the electric current.

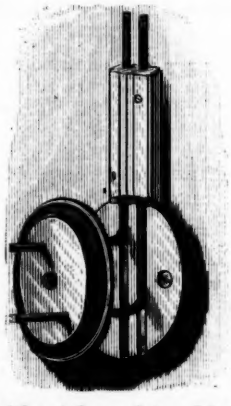
The Brush Electric Company v. The Fort Wayne Electric Light Company.—This suit was brought in the Circuit Court U.S., Indiania District, for an alleged infringement of letters patent granted to Charles F. Brush, September 2nd, 1879, for improvements in double carbon electric lamps of the arc type. Brush had assigned the patent to the complainant. It was not denied by the defendants that the patent described a new and useful mechanism for which Brush was entitled to a patent, but it was urged that he claimed for functions and results without regard to mechanism. His Honour (Judge Gresham), ruled otherwise; in his opinion, what was claimed were not functions and results, but mechanism for producing functions and results. He concluded thus:—It is not material for the purpose of this suit whether Brush was a pioneer, or a mere improver. It is sufficient that he described and illustrated in the patent in suit a specific mechanism, or double-carbon lamp, adapted to burn its carbons independently and successively; that he was the first to accomplish this result, and that the claims are for mechanism substantially as described in the patent in combination with two or more pairs of carbons or sets of carbons for producing the result specified. Brush is, therefore, adjudged the inventor of the double carbon arc lamp.

Electric Engine Controller.—Mr. E. Dixon, of Messrs. Blundell, Spence & Co., Hull, has designed and patented an apparatus for stopping engines at a distance. It consists essentially of a weight, which, while the engine is working, is held up by a catch lever, this lever being lifted, when the engine is to be stopped, by means of an electro-magnet. At the establishment of the company named a controller is fixed to each of these engines at work, while throughout the different departments of the mills push buttons afford the means of making electric contact, and so stopping an engine and ringing an alarm to warn the attendant.

Brush Company apply for a Quotation.—The Brush Electrical Engineering Company has made an application to the Stock Exchange to appoint a settling day and grant a quotation to £75,000 six per cent. first mortgage debentures.

Charity of the Right Kind.—On Saturday last, the 11th inst., Mr. Ronald A. Scott celebrated the close of a highly successful year, and the anniversary of the opening of his new and spacious works at Acton Hill by giving a dinner to 200 of the poorest children of Acton. After the dinner Mr. W. J. Thomas, solicitor, kindly amused the youngsters with a very comic series of lantern slides, the heartily sustained cheers and laughter affording ample proof of the satisfaction of the audience. The works were very prettily decorated with flags, and being illuminated throughout with arc lamps presented quite a gala appearance.

Improved Back Block.—Mr. Bathurst, who seems to devote special attention to perfecting the details connected with wiring for electric light, and whose cross-over blocks as described in the ELECTRICAL REVIEW some time since, have come into general use, now sends us an improved wood back block, the arrangement of which will be seen from the illustration. It consists of two pieces, the bottom one which is grooved to correspond with the grooves in the casing, being screwed up flush underneath the end of the casing by simply sawing off a portion of the block to make it fit. This bottom block is the same thickness as the casing, and the grooves in the casing are continued in the block, so that the wires come right down into the switch, cut out, or ceiling rose, and are everywhere



placed in wood without fear of touching damp plaster or brickwork. The bottom block is covered by a polished mahogany or walnut cover and the wires brought through as shown, and the casing cover fitted to the edge. The whole has a neat appearance, and the operation is an improvement on the old way of simply using the top block, hastily grooved at the back, and jamming the whole up against the wall after bringing through the wires. The small extra cost of the double block is recouped by the saving of time and trouble.

The Strike at Greenwood and Batley's.—The threatened strike of nearly 2,000 operatives at Messrs. Greenwood and Batley's, Limited, Leeds, has been avoided by judicious action on the part of the company. The men have now withdrawn their notices.

Agitation in the Telegraph Service.—At a large and enthusiastic meeting of telegraph clerks, held in Newcastle on Saturday night, the 11th inst., to consider their grievances, resolutions were adopted in favour of at once combining with the clerks in London and other offices throughout the kingdom to memorialise the Postmaster-General to secure a reduction of hours, increased pay, quicker promotion, extended annual leave, and overtime payment at the rate of time and a quarter for all Sunday work.

Subway Explosions in New York.—Two subway explosions occurred on Saturday evening, the 11th inst., at Fourteenth Street and Sixth Avenue, New York, the manhole covers being sent flying in the air, and the earth for 10 feet about was upheaved and scattered in all directions. The street was crowded, but nobody was hurt.

The Institution of Electrical Engineers.—On Thursday next an ordinary general meeting will be held at 8.0 p.m., when the adjourned discussion on the president's address will be continued.

Old Students' Association.—On Wednesday, January 29th, 1890, at 8 p.m., a special general meeting will be held at the Central Institution, Exhibition Road, S.W., for the consideration of certain important changes in the rules of the association, which the committee will propose.

German Technical Journalism.—The *Centralblatt für Electrotechnik* and the *Electrotechnische Zeitschrift* have now amalgamated, and the new journal will henceforth be issued from Berlin with the last-named principal title, but it is to be feared that the change will not be a beneficial one, for it is whispered that Siemens and Halske control the combination. Herr Uppenborn will remain as editor-in-chief.

Mr. Hammond on Electric Light Supply.—Mr. Robert Hammond, in the *Sussex Daily News*, of Wednesday, contributes an article on "Electric Supply," in which appears some good advice to ratepayers.

Electric Lighting of the General Post Office.—In a few weeks electric lighting will have replaced the old gas jets at the General Post Office. Workmen are now engaged in the different departments fixing the wires. "In the new building, 'over the way,'" says an evening contemporary, "known to pressmen as Bath Street, or the 'T. S.,' the room in which newspaper copy is dealt with, has been lit by electricity for some time."

The End of the Gas Strike.—The gas workers are coming to their senses in spite of their leaders. At the last meeting of the gas stokers the latter took care to be absent, and it was left to the secretary to tell the unfortunate stokers that they and their union were in a deplorable condition. Of the £2,700 which they had in the bank at the commencement of the strike only £700 remained. He feared Mr. Livesey would win after all.

Electric Light Fittings.—Messrs. Lea, Sons & Co., of Shrewsbury, have sent us a copy of a handsome portfolio of designs for electric light fittings, which they manufacture in brass, copper, iron, and glass. We have on former occasions called attention to the pains bestowed by this firm on the realistic imitation of natural foliage and flowers, and the patterns now published contain many good examples of this style of ornamental fittings for house lighting.

Registration of Companies in 1889.—According to the *Investors' Guardian*, the total amount of capital in electric companies registered in 1889 is £5,388,600, and in telephones £675,500. Our contemporary also adds "that the decrease under the head of telephone companies has been from £20,240,000 to the limited amount of £675,000; but this was to have been expected, from the fact that in 1888 there was a double registration of one company with a gigantic capital. There was also a decrease in the capital of new companies for electric lighting—the figures being for 1889 £5,388,600, as against £8,026,500 in the previous year."

The Notting Hill Electric Lighting Company, Limited.—Letters of allotment in this company have been posted.

NEW COMPANIES REGISTERED.

Fowler, Lancaster, and Company, Limited.—Capital, £22,000 in £10 shares. Objects: To construct and manufacture machines and apparatus, works and materials connected with electricity, magnetism, or other agency, and generally to carry on business as electrical engineers, manufacturers, and contractors. To supply electricity for lighting, and for the production and transmission of power for locomotive purposes, or otherwise, and to make experiments in, and public exhibitions of, electric and other similar lighting. Signatories (with 1 share each): A. Mackenzie, Temple Chambers; W. M. Pyke, 2, Metal Exchange Buildings; A. E. Shill, 30, Dayton Grove, Peckham; H. L. Collins, 67, Lombard Street; C. W. Rawlinson and R. W. Bonder, 11, Lincoln's Inn Fields; A. A. E. Good, 48, Lincoln's Inn Fields. The signatories are to appoint the first directors; qualification, 50 shares; remuneration, £150 per annum to the chairman, and £100 per annum to each ordinary director; and, in addition, 10 per cent. of the divisible profits remaining after payment of £10 per cent. per annum dividend. Messrs. G. Vaughan Fowler, and E. W. Lancaster are appointed managing directors, upon terms specified in an agreement of 4th inst. (unregistered). Registered 8th inst. by Pyke and Minchin, 2, Metal Exchange Buildings, E.C.

Purnell High Speed Gas Engine and Manufacturing Company, Limited.—Capital £50,000, in £1 shares. Objects: To adopt an unregistered agreement of 2nd inst. between J. J. Purnell and Joseph White. To carry on business as mechanical engineers, general engineers, gas engineers, electrical engineers, and as electricians and suppliers of electricity for heat, light, motive power or otherwise. To manufacture and deal in all apparatus required for the generation, distribution, supply, accumulation and employment of electricity. Signatories (with one share each): J. White, 2, Goldsmith Street, Gough Square, E.C.; A. W. Mantle, 52, Queen Victoria Street; Sidney Smith, 2, Robin Hood Court, Shoe Lane; J. E. Jackson, 3, Eton Road, Hampstead; A. H. Skan, 40, Algernon Road, Lewisham; J. H. Jack, 41, Chesilton Road, Fulham; H. C. Fowler, 8, Plevna Villas, Tottenham. The first directors are the Hon. Dudley O. Murray, 4, Crown Office Row; C. Bradley, Feltham; William Green, Hornsey Rise; and J. B. Guthrie, Ethelburga House, Bishopsgate Street. Qualification: 50 ordinary shares, remuneration £400 per annum, divisible. Registered 13th inst by Paddison Son & Fullilove, 14, Gray's Inn Square, W.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Automatic Electrical Company, Limited.—The annual return of this company made up to the 7th inst. was filed on the 9th inst. The nominal capital is £75,000, in £20 shares, the whole of which are issued and are considered fully paid up. Registered office, Winchester House, Old Broad Street.

Northern House-to-House Electricity Company, Limited.—The statutory return of this company made up to the 11th ult. was filed on the 6th inst. The nominal capital is £100,000, in £5 shares, 100 being founders' shares. Only seven ordinary shares are at present taken, and upon these no call has been made.

Scottish House-to-House Electricity Company, Limited.—The statutory return of this company made up to the 11th ult. was filed on the 6th inst. The nominal capital is £100,000, in £5 shares, 100 of which are founders' shares. Seven ordinary shares are taken up, but no call has been made thereon.

Lineff Electric Traction and Lighting Company, Limited.—The annual return of this company made up to the 31st ult. was filed on the 6th inst. The nominal capital is £10,000, in £1 shares. 8,824 shares have been allotted, and are credited as fully paid up. Registered office, 11, Queen Victoria Street.

Barnet and District Electric Supply Company, Limited.—The annual return of this company made up to the 3rd inst. was filed on the 6th inst. The nominal capital is £5,000, divided into 490 ordinary shares of £10 each and 100 founders' shares of £1 each. 80 ordinary and the 100 founders' shares are taken up. Upon 60 ordinary shares the full amount has been called, and upon 20 ordinary shares £5 per share has been called, the calls paid amounting to £700. The founders' shares are credited as fully paid up. Registered office, 31, Wilson Street, Finsbury.

Woodhouse and Rawson, Electric Contract and Maintenance Company, Limited (In Liquidation).—The registered office of this company is now situate at 41, Piccadilly, Bradford, Yorkshire.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending January 10th, 1890, amounted to £4,728.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the week ending January 10th, 1890, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,464.

ELECTRIC TRACTION AT BARKING A COMMERCIAL SUCCESS.

As the readers of this journal are doubtless aware, some half a dozen electric tramcars are at present running on the North Metropolitan Tramway Company's line on the Barking Road from Canning Town to Plaistow. The cars have been made, and are worked under contract, by the Electric Traction Company, Limited. The cars are similar in appearance to ordinary horse cars, and the batteries, which are placed underneath the seats, are easily accessible from the outside, doors running half the length of the car being provided for this purpose. In each car are arranged two batteries of 48 cells, of the E.P.S. type, which can be connected to the motor either in series or in parallel. The controlling device of the car is a compound switch, to which the four leads from the batteries are brought together. The motor, which is of the Immisch type, is connected with the batteries in parallel by moving the switch handle in one direction, and with the whole of the cells in series by an opposite movement. The E.M.F. of the 96 cells on each car is 192 volts in series, and 96 volts if run in two sets parallel. The motor is nominally of about 6 H.P., but this varies according to the current required, and ranges from 1 H.P. to as much as 10 H.P. The motor is ordinarily run at about 1,000 revolutions. In addition to the regulating switch, there is a make-and-break for disconnecting the cells when not in use; there is also a reversing lever attached to the brushes, by which the direction of the car is immediately changed. Both ends of the car are arranged in this manner. The total weight of the car, including accumulators and motor, and excluding passengers, is five tons.

The line on the Barking Road is single, having loops at suitable intervals, and was the only track which the tramway company could place at the disposal of the Traction Company. The ordinary car-drivers have no difficulty in taking charge of the cars, which run easily at 8 miles an hour, but a speed of from 15 to 20 miles an hour can be attained. For charging the cells there is provided a Davey-Paxman 8 H.P. steam engine, which drives an Immisch dynamo running at 600

revolutions, and having an output of 40 ampères and 250 volts. These machines were installed on the opening of the line, but now additional machinery of 100 H.P. has been erected, together with corresponding dynamos, in order to avoid any interruption in the service in the case of the breakdown of one set of machines.

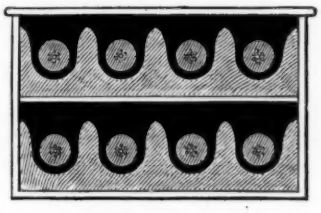
Turning now to the question of economy, we are enabled, by the courtesy of Mr. Macpherson, the managing director of the Traction Company, to place before our readers some important details which, as yet, have not been published. The contract price is 4½d. per car mile, out of which the driver's wages have to be paid. The North Metropolitan Tramway Company states that the cost of working horse-cars (carrying 52 passengers) throughout their system *averages* 5½d. per car mile, whilst on the Barking line itself the cost is 6½d., and not 6d., as recently reported in one of our contemporaries. The line, it may be mentioned, which is only a mile and a quarter long, is not very smooth, and has both up and down hill gradients and level running. The direct saving to the tramway company is 2d. per car mile. This is a considerable item—especially as when horse traction was employed the line itself was a losing concern—as the following figures will show:—From the opening of the line on the 14th June to the 31st December last the total mileage run by the cars was 34,366 miles out of a maximum of 35,091, or a total loss of mileage through failures of plant, &c., of only 725 miles. It will thus be seen that the saving effected by the North Metropolitan Company, during the period mentioned was, at the rate of 2d. per car mile, £286 7s. 8d., this being a great commercial success for the tramway company. So much has this been the case, that the latter has applied to Parliament for powers to employ electric traction on the whole of the system. The number of passengers carried by the electric cars was over 350,000. There is, however, another point in favour of the company: The six electric tramcars have displaced sixty horses which were formerly employed to haul the horse cars, ten horses being required for each car. These horses have now been set to draw omnibuses from Canning Town to Poplar. The electric cars having been substituted for horse cars, the stabling of the horses has thus been set free in the sense that had the tramway company not worked the Barking line by electricity, and if it had been desired, to place ten omnibuses to run from Canning Town to Poplar, additional stabling would have been required for the sixty horses. This in itself is a serious item, as land for the erection of stabling is expensive to purchase, especially in large towns like London.

It must be admitted, from the foregoing, that the North Metropolitan Company is very favourably situated as regards the Barking line, the operation of which has resulted so satisfactorily—both from a financial and a working point of view. The mileage run would have turned out even more advantageous had not it been for the fact that the hours worked by the employés on that line are slightly less per day than is the case on the other lines belonging to the company. It may be asked: Has the contract been a commercial success for the Electric Traction Company, who, running the cars at 4½d. per car mile, have also to pay the driver's wages? This, we are able to state, is really the case. We have been shown the official lists indicating the maximum mileage attainable by each car, the mileage actually run, the cost of driver's wages, coal bill, expenses at charging station, &c., but we are not permitted to publish the figures at present. The figures demonstrate that a profit has been made on each month's working, and that the whole undertaking has been a distinct success. It may be mentioned, in conclusion, that the Traction Company will shortly despatch to Liverpool the first electric car which is to be employed in Liverpool by the United Tramway and Omnibus Company of that town, and who propose to substitute electric tramcars throughout their system of 61½ miles.

THE ELECTRIC LIGHT AT BATH.

THE electric lighting station is being rapidly completed and it is expected that by March next, some 4,000 incandescent and 200 arc lamps, distributed over 60 of the principal streets, squares and crescents of the city, will be supplied from it. The designer and moving spirit is Mr. Massingham. The machinery and plant consist of two Babcox and Wilcox patent water tube boilers, each of 150 H.P., supplying steam to six compound condensing engines. Four of these engines, each indicating 35 horse-power, will drive the arc light dynamos; and the two larger engines, each capable of developing 150 horse-power, will supply power to two large alternate current dynamos, generating currents for the incandescent or "glow" lamps.

This alternating current is to be supplied from the station at a pressure of 2,000 volts, which will be reduced on entering the consumers' premises to a potential of 100 volts, by means of Mordey's transformers. The cables are laid under the footway in cast iron troughs about five inches wide. They are heavily insulated with India-rubber, and insulating compound in the usual manner, and present at cross section an appearance similar to sketch. That for the arc lighting consists of 7 strands of No. 16 B. W. Gauge, and the cables used for the glow lamps 19 strands No. 17 B. W. G.



The troughs are of sufficient width to take four of these cables packed side by side, but kept apart by wooden separators, or bridges, placed at intervals of a few inches, The spaces between the cables and troughs are then filled in with bitumen poured on in a liquid state, which on solidifying encases the cables in a solid damp-proof mass, in the centre of which the conductors are buried. The troughs (shown in the illustration) are of sufficient depth to take two layers, or eight cables, or less number, according to requirement of the districts.

The arc lamps in each street will be arranged to be fed from two distinct circuits, each supplied by separate engines and dynamos, and in the event of one circuit failing only the lamps on one side of the street will be affected.

Two main circuits will be run through the town. From these circuits branches will lead east and west through the intervening streets.

The arc lamps are to be carried on lamp-posts 23 feet from the ground, overhanging two feet into the road.

The installation is being carried out solely by Mr. Massingham, who has obtained from the Corporation a seven years' contract for lighting 59 of the principal streets with Thomson-Houston arc lamps, and who has also undertaken to supply private consumers throughout the whole of this district.

The cost of this installation will be about £25,000.

INTERIOR WIRING IN BOSTON.

THE committee appointed to report upon "Electric Wires inside of Buildings," recommends as follows:

For arc light and power wires, or others designed to carry current of over 250 volts electromotive force:

That they shall not be placed so as to be concealed from view.

That they shall not be allowed in contact with wood or other inflammable building material that may become carbonised, but that they shall be separated from such material by at least one-half inch air space by use of non-combustible, non-carbonisable insulators, placed near enough to prevent contact of the wires by sagging or otherwise, but not further than six feet apart.

That with such construction, wires of opposite polarity shall not approach each other nearer than ten inches, except at the lamp and switch.

If the wires are encased in insulating tubing that is impervious to moisture, will not support combustion, and of sufficient mechanical strength to protect them from injury, the tubes may be laid as near as three inches to each other and may be fastened to any building material by use of staples or such other means as will not injure the tubing.

All such wires must enter and leave the building at the same

place in order that a non-combustible hand switch may be placed outside for the use of shutting off the current.

An insulating covering, that will support combustion, will not be allowed.

For incandescent light and power wires, or others designed to carry currents of less than 250 volts electromotive force:

If such wires are concealed within partitions or like places they must not be allowed in contact with wood or other inflammable building material that they may become carbonised, nor with any conducting material such as piping or other wires.

They must be rigidly separated from such material by at least one-half inch air space, by the use of non-combustible, non-carbonisable insulators, placed at intervals near enough to prevent contact by sagging of the wires or otherwise.

The wires must be kept at least six inches apart, except where they enter junction boxes, cut-outs or the like.

Wires laid in plaster, cement or other similar building material will not be allowed, no matter what insulating covering may be used.

In lieu of construction by air space and non-combustible insulators, wires may be incased in insulating tubing that is impervious to moisture, will not support combustion, and of sufficient mechanical strength to protect them from injury, and such tubes may be laid side by side, in plaster, cement or similar finish, or in any concealed space where they will not be subjected to injury, and may be supported by staples or such other means as shall not injure the tubing.

No switch or safety cut-out except those made of non-combustible material will be allowed.

For telegraph, telephone, messenger service and all other electric wires not heretofore mentioned, except public fire alarm and police wires and "series" electric light wires:

All such wires in any town or city in this Commonwealth where electric lights or power wires are being operated, must be provided at the entrance of any building (both ingoing and outgoing wires) with some safety device which shall instantly open the circuit or shunt the current out of the building in case the flow of current shall at any time exceed in quantity or electromotive force that which is normally used on such wires.

Such safety device must be located as near as possible to the place where the wires enter the building, and in some place easy of access.

When the safety device is placed inside of the building, the wire connecting it with the outside wire must be of equal or greater carrying capacity.

The device must be mounted on non-combustible material.

All switches, cut-outs, insulators, insulation or tubing for use in electric lighting or power work, and all safety devices herein referred to must be approved by the committee or inspector in power, before being used.

TRANSFORMERS.*

By HARRIS J. RYAN.

THE apparatus by means of which electrical energy of one form may be transformed to that of any other form, few engineers fail to appreciate.

So great have been the anticipated possibilities offered by the application of the modern transformer of alternate current energy that in most cases in our country especially has the transformer found immediate application, with but little thought or study of its exact performance. Much experimental work has been done by trial methods to the end that our manufacturers are able to supply transformers that answer for such that is desired practically with a commercial efficiency that can be made higher than is probably possible by any other transformer of energy.

In electrical engineering, as well as other branches of engineering for the broad application of one method or another, it is always of the highest importance that the cause and extent of every effect is thoroughly understood with regard to the mutual action and interaction of all forces and materials in relation to themselves, or to energy of one for another.

It was with a view of obtaining, so far as possible, a clear understanding of all phenomena that take place in the commercial transformer, that the work producing the results here set forth was undertaken. It has not been possible at this time to prepare a paper as complete as has been desired, and we trust that in the near future we may add more data to that which is here presented.

In the outstart of this paper it should be said that the results of the experiments that are here presented were wrought out jointly by Ernest Merritt, of the Department of Physics, Cornell University, and the writer. What we had in mind in the work was an accurate determination of the exact performance of the commercial transformer, whereby one should be able to derive results and data that should enable all phases of the performance of the transformers to be understood clearly, and that should show the requisite principle of proper design. It may be well to state briefly the general method we employed. A single 10-light transformer that had been made and supplied for commercial purposes for incandescent lighting, with 1,000 volts in the primary and 50 volts in the secondary, was selected as a sample for investigation. It probably represented fairly well the average commercial performance of transformers, and might therefore be said to embody, to a certain extent, at least, proportions that have proven by experience and experiment to be best for the particular purpose for which it is supplied.

* Read before the American Institute of Electrical Engineers, New York, December 17th, 1889.

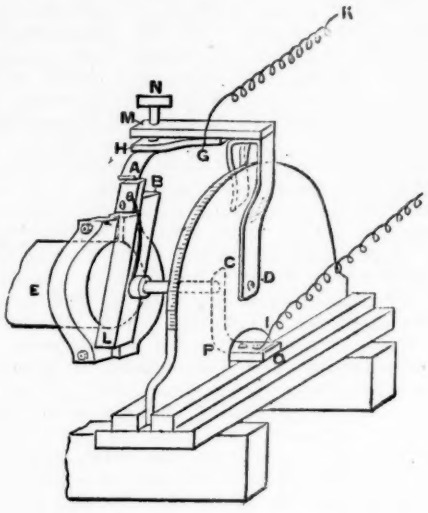


FIG. 1.

This transformer was operated under the same impressed E.M.F. supplied from the electric lighting plant in which it had been used for supplying incandescent lamps commercially. It was operated with its secondary open and the same closed through one lamp, five lamps, and ten lamps, and under the several conditions the exact instantaneous values of the ever-varying primary impressed E.M.F., primary current, and the E.M.F. at the terminals of the secondary were observed. Again, under these several conditions, the square roots of the mean squares of the above values and of the secondary current were also observed. Then, with these observations, the dimensions and the details of the construction of the transformer many of the facts and performances that the engineer is concerned with are brought to light.

Naturally the first things to be considered are the electrical measurements, and how they were made. A point on the armature of an alternator always passes a fixed point in its circumference at a time corresponding to a definite value of the varying E.M.F. and current alike, with regard to these quantities in the primary feeders, transformer, primary or secondary, &c., so long as the conditions remain constant. In our experiments we were only concerned with the values of the E.M.F. impressed at the terminals of the primary, the primary current and the secondary E.M.F., then by changing the position of the fixed point relative to the machine, the rotating point of reference in the armature would pass the new position of the fixed point at corresponding different values for the primary E.M.F., primary current, and secondary E.M.F., with respect to themselves and the position of the armature.

In fig. 1, B, L is a prism of hard rubber bearing a projecting strip of brass, B, that on its upper side is filed to a dull edge. This edge is taken as a fixed point on the armature. An arm, F, D, is arranged to rotate about D as a centre, a point that is in line with the axis of rotation of the armature. A semi-circular board of hard wood, attached rigidly to the dynamo frame, serves both as a support for this arm and a circumferential scale whereby the position of the arm may be shown relatively to the machine. The arm was made of brass and given the form shown in the figure. It was bent into a U shape at the top, so as to pinch the board, and thus remain fixed in any position desired. At the top of this arm is mounted a bar of hard rubber projecting toward the dynamo parallel to the armature axis. On its under side, fastened at G, is a brass strip, a tongue, H, A, of spring brass is attached at the end and at right angles to the brass strip, H, G, as shown. The position of this part of the apparatus is carefully adjusted so that the point about which the arm rotates is in line with the axis of rotation of the armature and the sharply upward curved end of the tongue, H, A, just over the edge of the brass strip at B. Then when the armature is rotated the strip, H, G, may be sprung inward radially by turning the thumb-screw, N, until the tip of the tongue, A, is heard to just lightly touch the edge at B as it passes. The arm may then be adjusted by hand so that the tongue will touch the fixed edge on the armature at any desired phase of the primary E.M.F., primary current, or secondary E.M.F. and current. Co-axial with the armature a small brass rod is mounted on the bar of hard rubber, B, L. It is connected metallically to B by means of a wire. At O on the framework supporting the semi-circular board, &c., is mounted another piece of hard rubber, insulating and supporting the thin metallic strip, P, C, that bears

against the above brass rod. G and I then are the terminals of the commutating apparatus.

In fig. 2 E, F, is a non-inductive resistance in series with the primary of the transformer which is at work. At A is the apparatus described in fig. 1, and E is an electrometer reading through a wide range.

The terminals of the non-inductive resistance and those of the electrometer are connected together through the commutating apparatus at A. Then it must be evident to all that the electrometer will become charged with a difference of potential equal to that existing between the terminals of the non-inductive resistance at the instant that the fixed edge on the armature passes the tip of the tongue in the apparatus at A. By reading the indications of the electrometer, therefore, and knowing the value of the non-inductive resistance, E, F, the value of the primary current corresponding to the particular phase due to the position of the arm in the apparatus at A becomes known. In a similar manner the primary and secondary E.M.F. are observed by changing the connections accordingly at G^1, G^2, G^3, G^4. Then the arm is rotated to another position, corresponding to a different phase, and the corresponding values of E.M.Fs. and current again observed as before. In this manner we proceed at equal intervals, sufficiently near, so that a curve may be determined by the values thus observed at the several intervals such that the values of the E.M.Fs. or currents shall be accurately known at all times throughout a complete period.

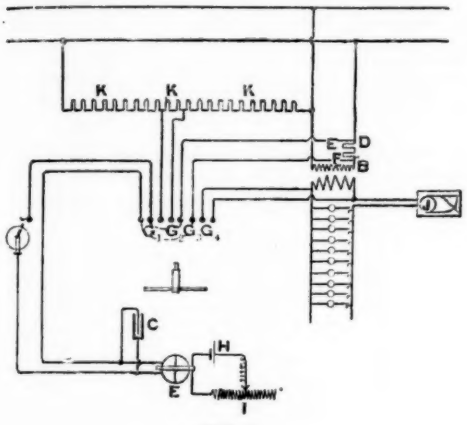


FIG. 2.

A few words with regard to the electrometer at E are not out of place here. It is the form that the writer devised especially for this and similar purposes. The essential features for an electrometer for these purposes are that it shall have the widest possible range through which it will read with accuracy. Its indications must be unvaried by the absolute potential to which it is subjected as a whole. Its law must be perfectly definite, and it is also desirable that its constant be unchanging.

Fig. 3 illustrates this instrument in diagram. It consists essentially of a cylindrical electrometer needle and quadrants, E, D. To the upper side of the electrometer needle is attached a magnetised steel mirror that acts as a magnet and as a mirror for observing the position of the same. The needle is hung by a single silk fibre, H, from a hook in the top of the case as shown. Metallic contact from the needle to the case is made by means of a platinum wire ·0002 inch in diameter. This wire is readily provided in the desired form by using the platinum cored silver wire that is supplied by makers of surveying apparatus. It is cut the desired length and hooks bent into shape at its terminals. By immersing all of it but the hooked terminals in nitric acid the silver is dissolved away, leaving the fine platinum core terminated by the two silver hooks. One end of this platinum wire thus prepared is linked into a hook into the top of the electrometer case and the other end into a small ring formed by a twist of the aluminum wire that surrounds the mirror, C. The electrometer case is circular, and the above needle and quadrants are arranged so that the magnetised mirror is at the centre of the case, and the needle and quadrants below it. About the case, as the figure indicates is wound a coil, B, B, of rather fine insulated copper wire. The magnetised mirror and this coil then, when the latter is in the magnetic meridian, constitute an arrangement similar to that of a tangent galvanometer. In the electrometer the needle, case and one set of quadrants are connected together, and form one terminal and the other set of quadrants, being connected together, form the other terminal of the instrument in the manner set forth in the diagram. Thus, then, when the electrometer terminals are subjected to a difference of potential, the needle is acted upon by a couple brought about by the electrostatic forces and is deflected from its position of equilibrium. Then, as is shown in fig. 3, current from a gravity cell in circuit with a suitable rheostat is sent through the coil on the electrometer in such a direction that the needle is brought toward its zero position by the action of the coil, carrying the current, on the magnetised mirror. The current is then further adjusted till the needle stands balanced at zero under the mutual action of the electrostatic and the electro-magnetic forces. Under such circumstances then, the difference of potential is proportional to the square root of the current.

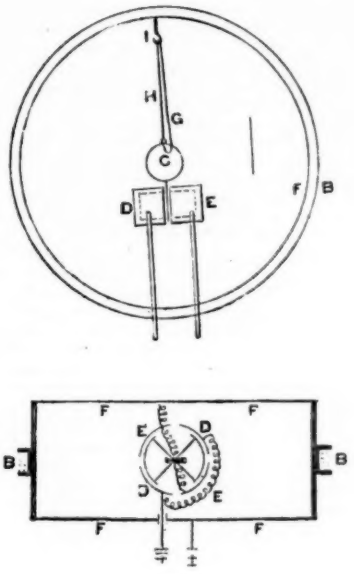


FIG. 3.

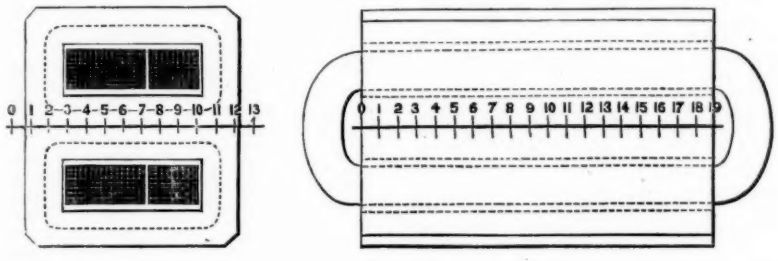


FIG. 4.

If we can, as was the case when the measurements here presented were made, consider the E.M.F. of our cell constant, the difference of potential is likewise proportional to the square root of the reciprocal to the total resistance in circuit with the cell. Parallel readings, taken with a standard voltmeter throughout a range varying from 3 to 600 volts gave identical results showing no deviation from the above law, and an unvarying constant. On account of the metallic case and its connection to the rest of the apparatus, the indications of the electrometer are, so far as could be observed entirely independent of the absolute potential to which it is subjected as a whole. In fig. 2, when contact was made at A and the electrometer charged to the potential difference to which its terminals were then subjected it was found that much of the charge was dissipated by leakage during the course of a revolution of the armature, no matter how good the insulation of the apparatus was. A one-half microfarad mica condenser was then placed in multiple arc with the terminals of the electrometer at C. Then after a few revolutions of the armature the condenser became charged to precisely the same difference of potential existing at the terminals of the electrometer, D, B, as shown in fig. 3, when the rotating edge on the armature passed the tip of the tongue on the arm at A.

Under these circumstances the leakage that occurred was entirely unobservable as compared with the charge in the condenser during the course of time required for the armature to make many revolutions. Thus arranged then, the electrometer would give accurate readings of the primary and secondary E.M.Fs. and primary current corresponding to the connection of its terminals and the position of the arm at A. Again, the square root of the mean square of any of these values could at any time be read from the electrometer by short-circuiting the apparatus at A and cutting out the condenser at C. For the purpose of obtaining the curve of impressed E.M.F. and the $\sqrt{\text{mean}^2}$ of the same, 22 50-volt lamps were put in series across the primary circuit. The $\sqrt{\text{mean}^2}$ of the impressed E.M.F. in the primary was then obtained by reading by means of the electrometer with the condenser cut out and the commutating apparatus short-circuited, the $\sqrt{\text{mean}^2}$ difference of potential existing between each set of two lamps. In this way 11 readings were obtained, the sum of which was the total impressed E.M.F. This served as a calibration of the non-inductive resistance formed by the lamps. At the same time that these observations were made, two lamps were determined upon to be used in all subsequent observations on the total E.M.F. The above observations served then as a calibration for the indications of the two lamps thus to be used. For the constant obtained by the ratio of the above total E.M.F. to the E.M.F. of these lamps taken at the same time always served to deduct the total $\sqrt{\text{mean}^2}$ or any particular value corresponding to a particular phase of the impressed primary E.M.F. when the same had been observed with regard to the two lamps in the group thus set apart. In this way we avoided the direct measurements of the total impressed E.M.F.

Two 50-volt lamps, E and F, were placed in series with the primary for a non-inductive resistance, and as previously stated the $\sqrt{\text{mean}^2}$ and the value corresponding to any particular phase of the fall of potential through these lamps were observed. This gave a measure of the $\sqrt{\text{mean}^2}$ or any particular value corresponding to a particular phase of the primary current, when the resistance of these lamps was known at the temperature to which they were brought by the current. A curve of resistances corresponding to the range of currents through which we used these lamps was determined carefully by Mr. Merritt at the Cornell Magnetic Observatory.

In series with the secondary circuit was placed a gravity ammeter containing a few small turns, and correct in its adjustment; it indicated the $\sqrt{\text{mean}^2}$ in the same way that an electro-dynamometer would have done. Observing the various values of the secondary E.M.F. required no special arrangement—this was done directly in all cases. Since the secondary was always at work on a circuit possessing almost no inductance no determinations of the curve of secondary current made for it would be found to be so nearly in unison with the secondary E.M.F. and possess all the characteristic variations of the same. The $\sqrt{\text{mean}^2}$ of its value was always known from the indications of the ammeter. As a load for the transformer 10 16-candle-power 50-volt lamps were provided that could be turned on and off as desired, and they were at an average distance from the transformer not more than 5 feet.

G^1, G^2, G^3, G^4, represent, in fig. 2, the various terminals conveniently arranged on a switch board for ready adjustment for any desired set of connections. The adjustable resistance at I consisted of a plug resistance box enabling one to get any number of ohms in circuit from 100,000 down. It was very conveniently arranged, but a suitable slide rheostat and a damped magnet on the electrometer needle would have facilitated greatly the rapidity with which observations could be taken. The mode of procedure was to set the brush at some suitable point of starting out, then corresponding to this point readings of the instantaneous values of primary E.M.F. were made. Then lamps were turned on in the secondary, the ammeter in that circuit was also read. The brush was then moved forward to a new position, and the above readings repeated. This was continued until we had gone over a complete period of two alternations, then the $\sqrt{\text{mean}^2}$ readings of the primary and secondary E.M.Fs. and primary current were made. To do this required a period of time covering usually not more than 2½ hours. Careful observations were made which showed that the insertion of one, two or three lamps in the primary circuit *did not perceptibly change the relation* of the primary E.M.F. and current and secondary E.M.F. The indications of the ammeter gave data for correcting for variations of the speed of the dynamo that throughout was not great.

The following data should be given with regard to the transformer that was used by us:—

No. of turns in the primary coil	675·
No. of turns in the secondary coil	35·
Resistance of the primary	21·8 ohms.
Resistance of the secondary	·04 ohm.

Fig. 4 is furnished with a scale to which it was drawn so that from it any details as to dimensions of the transformer can be obtained.

The iron discs of the magnetic circuit of the transformer were made one-half millimetre in thickness, and its surface merely oxydised so that no special insulating material was provided between the laminations. The total volume of laminated iron used in the transformer was 2,050 cu. cms.

The mean cross section of the magnetic circuit was 63·3 square cms., and the mean length of the magnetic circuit 30·8 cms.

The following observations with the secondary on open circuit and working on one lamp, five lamps, and ten lamps were made.

SECONDARY ON OPEN CIRCUIT.

Brush reading.	Primary E.M.F.	Current.	Secondary E.M.F.
21	119	·20	5·5
20	855	·05	62·7
19	1,250	·07	63·4
18	1,420	·11	70·7
17	1,330	·14	66·8
16	900	·19	46·0
15	45	·21	00·0
14	751	·04	37·8
13	1,210	·08	62·0
12	1,390	·12	72·0
11	1,410	·15	72·5
10	1,100	·18	57·8
9	355	·21	14·5
8	645	·08	32·3
7	1,130	·04	57·8
Observed $\sqrt{\text{mean}^2}$	1,025	·14	54·5
Calculated from curves $\sqrt{\text{mean}^2}$	1,030	·147	53·5

SECONDARY CLOSED THROUGH ONE LAMP.

Brush reading.	Primary E.M.F.	Current.	Secondary E.M.F.
28	605	·225	31·4
27	330	·125	15·3
26	917	·048	45·2
25	1,300	·179	67·6
24	1,403	·215	71·7
23	1,300	·235	67·1
22	820	·239	43·8
21	132	·185	4·7
20	835	·000	3·9
19	1,238	·151	61·5
18	1,420	·215	71·7
17	1,363	·238	68·4
16	1,026	·246	52·7
15	170	·215	9·7
14	793	·048	35·6
Observed $\sqrt{\text{mean}^2}$	1,053	·196	52·3
Calculated from curves $\sqrt{\text{mean}^2}$	1,021	·190	51·4

Mean of ammeter readings, 1·26.

SECONDARY CLOSED THROUGH FIVE LAMPS.

Brush readings.	Primary E.M.F.	Current.	Secondary E.M.F.
29	956	·449	40·3
28	41	·250	10·4
27	723	·000	28·9
26	1,194	·356	54·8
25	1,447	·495	69·1
24	1,350	·483	67·2
23	1,103	·453	57·6
22	293	·304	21·5
21	560	·000	19·8
20	1,110	·318	48·8
19	1,383	·464	65·7
18	1,429	·511	70·0
17	1,228	·500	60·3
16	567	·374	24·0
14·7	585	·030	23·4
Observed $\sqrt{\text{mean}^2}$	1,050	·390	51·0
Calculated from curves $\sqrt{\text{mean}^2}$	1,036	·383	50·6

Mean ammeter reading, 5·83

In fig. 5 are plotted curves deduced from the foregoing observations that show clearly the rate at which energy is given to the transformer, or that the transformer restores to the circuit at all points of a complete alternation for the several conditions under which the transformer was operated. The curves themselves show so clearly this particular part of the performance of the transformer that nothing need be said about them, except to give the percentages of the work given to the transformer that is restored to the circuit by it under the several foregoing conditions: Open circuit, 6·8 per cent.; one lamp, 3·9 per cent.; five lamps, ·96 per cent.; ten lamps, ·36 per cent.

SECONDARY CLOSED THROUGH 10 LAMPS.

Brush readings.	Primary E.M.F.	Current.	Secondary E.M.F.
21	138	·242	5·2
20	826	·276	29·7
19	1,237	·642	53·5
18	1,378	·795	64·0
17	1,300	·821	64·3
16	924	·700	51·1
15	63	·340	15·0
14	698	·188	23·7
13	1,138	·587	49·0
12	1,370	·810	63·7
11	1,343	·844	66·0
10	1,073	·771	26·5
9	323	·479	26·5
8	590	·000	17·0
7	1,117	·538	42·8
Observed $\sqrt{\text{mean}^2}$	1,040	·631	49·3
Calculated from curves $\sqrt{\text{mean}^2}$	1,020	·634	49·3

Mean ammeter reading, 10·65.

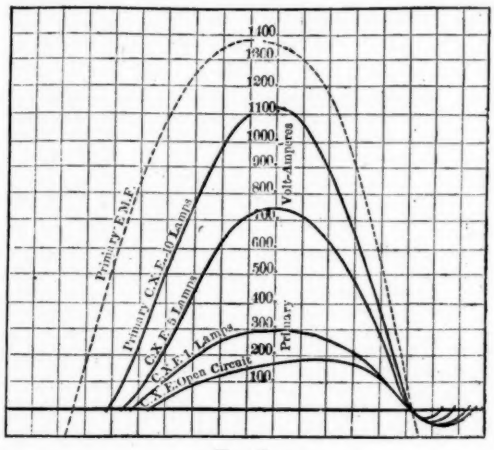


FIG. 5.

The above observations and data are ample wherewith to compute the various losses of energy that take place in the transformer under the several loads and under no load, and the deduction of the corresponding efficiencies. These values have been computed and are given in the following table.

Proper corrections have been applied for the two lamps in series with the primary of the transformer.

Secondary E.M.F.* (Primary 1,020).	Primary Watts.	Secondary Watts.	Efficiency.	Total loss in Watts.	Hysteresis loss in Watts.	Heating loss.	
						Primary Watts.	Secondary Watts.
			pr. cent.				
Secondary open 52·3	96·1	0·0	0·0	96·1	95·7	0·4	0·0
One lamp ... 52·3	159·1	64·3	41·1	94·8	93·9	0·9	0·0
Five lamps ... 50·1	388·6	300·9	77·5	87·7	83·1	3·3	1·3
Ten lamps ... 47·5	607·9	325·0	86·6	82·9	69·7	8·7	4·5

In fig. 6 these values have been plotted to scale there indicated, and the respective curves that they determine have been drawn so that one can plainly see the exact performance of the transformer under all loads.

It is interesting to note that this transformer might be loaded to twice its rated capacity and the heating of the coils would still be less than that of iron, although the heat produced by the iron grows less as the load comes on. Likewise, that its efficiency would not yet have reached its maximum, and that it would have a value of 92 per cent. In fig. 7 the outer curve represents the relations between the magnetising current in the primary and the degree of magnetisation for all points of a complete cycle. The values locating the curve expressing this relation were readily deduced from the observations made when the transformer was working on open circuit. In a diagram* the dotted curve represents the curve of primary current that would be found should Foucault currents be known to be absent, and the relation of ampère turns and magnetisation be the same going up as coming down. Then if Foucault currents were present the dotted curve would have a component at a quarter of a period in advance. This would produce a negative lag in the dotted curve. From the position of the actual primary current it is plainly seen that but a very small component of the above nature is possible, and that the energy that is wasted by eddy currents must therefore be small. The radical departure of the primary exciting current from the approximate sinuous variation of the primary impressed E.M.F. is plainly brought out to be due to hysteresis. From the preceding consideration it is also evident that almost the entire advance of the exciting current and therefore the corresponding dissipation of energy is due to the same cause.

It was thought of much interest to see what amount of hysteresis should be indicated by carrying the transformer slowly through the same cycle of magnetisation that it went at the rate of 138 cycles per second when at work on the circuit with its secondary open. Accordingly by Ewing's method modified for the purpose by Dr. Sumpner, Mr. Merritt determined the inner curve shown in fig. 6. We regret greatly not to have had time for a careful redetermination of this inner curve, and carry the magnetisation to the same maximum that was done in the transformer when on the circuit. The agreement between the cards would have been more marked even than in fig. 6.

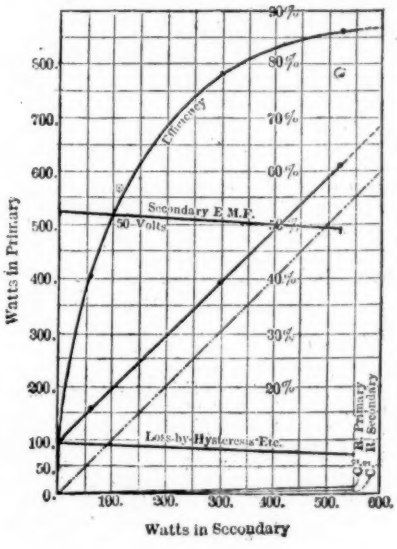


FIG. 6.

The assumption made by Mr. Swinburne in his remarkable and valuable paper on the "Design of Transformers" (Proceedings of the British Association, 1889) would therefore be fully substantiated. Mr. Mordey's experiments, in which hysteresis and Foucault current losses producing a common loss were determined, were performed by cycles of magnetisation produced by rotation in which the degree of magnetisation did not vary in amount but direction, and cannot be said to throw light on the correctness of Mr. Swinburne's assumption. Some, commenting on this paper, have used Mr. Mordey's results as evidence that these assumptions are wrong.

By a knowledge, then, of the magnetic properties of the iron with which a given transformer is to be built, and the methods made use of by Mr. Swinburne, its efficiency is something that can be correctly predetermined.

The importance of making a transformer produce the same E.M.F. at the terminals of the secondary under all loads, asserts itself when it is used for incandescent lighting. In the transformer under consideration, from the ratios of the primary and secondary turns, the E.M.F. that they produced, and the variations of magnetisation that had to take place through the primary in order that the same should produce an E.M.F. equal and opposite to that of the primary impressed E.M.F., the magnetisation produced through the secondary and the magnetisation set up about the primary in its own air space, are determined. In the present transformer this "leakage" of magnetism amounted to about 1·2 per cent. When the transformer works on full load 4·5 times as much current passes through the primary and the "leakage" of the primary in its own space is 4·5 times as much as on open circuit and becomes 5·4 per cent. This value, together with the small drop due to the actual resistance of the transformer

* The values given in this column have not been corrected for the two lamps in series with the primary for the first three conditions and the one lamp that was used for the last. With ten lamps, where one lamp was used in the primary, this correction amounts to an increase of the secondary E.M.F. of 3 per cent. On open circuit and one lamp it is negligible and 3 per cent. increase for five lamps. When this correction is applied, the drop of 3·5 volts obtained is what was observed by direct measurement on the secondary.

* Not represented.

coils, accounts for the fall of 3·5 volts that was observed by turning on all of the ten lamps.

Attention might be called to a similar "leakage" in magnetism that takes place in the secondary circuit. It is plainly brought out by the lag of the secondary E.M.F. This magnetic "leakage" producing a self-induction is proportional to the secondary current. The rate of change of this quantity then is proportional to the E.M.F. that it produces. This E.M.F. is therefore a quarter of a period behind the secondary current and results in producing a small lag in primary and secondary currents and secondary E.M.F.

Finally there is a curious behaviour of this transformer that remains to be accounted for. This is the considerable decrease in the loss by hysteresis as the transformer is loaded down, that is not to be accounted for by rise of temperature or the falling off of the magnetisation due to the increased "leakage" about the primary in its own air space.

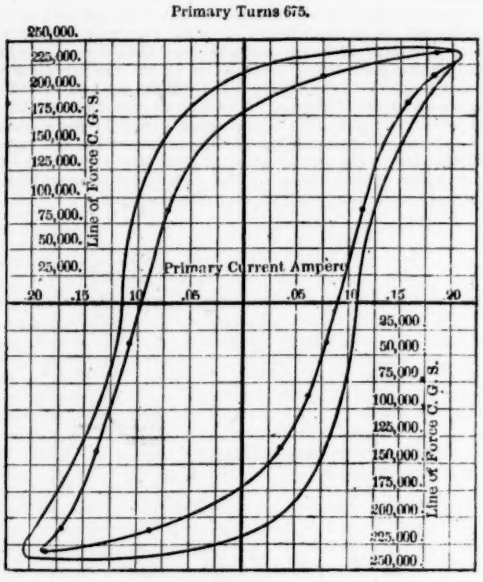


FIG. 7.

The following reason suggested itself to the writer why this should take place.

Mechanical shock has been shown to greatly reduce loss by hysteresis when iron is passed through cycles of magnetisation. Since the currents are at all times opposite each other in the two coils of a transformer, strong repulsion occurs when these currents are at a maximum, and no force is exerted when they pass through zero. So it follows that they continually keep thrusting each other apart when at work, and add to the disturbance of the laminated iron that already exists on account of its changing magnetisation. This increasing of the mechanical vibration of the iron may therefore account for the above-mentioned phenomenon.

On open circuit the maximum magnetisation of the iron per square centimetre was 3,850 C.G.S.

Loss by hysteresis per cycle per cubic centimetre neglecting Foucault currents ·046 watts at 138 alternations per second.

Coercive force per centimetre of the iron 2·76 C.G.S.

In conclusion, the writer would say that the data here given show for themselves so clearly the advisability of providing some practical means for breaking the primary circuit of the transformer when not in use, that the strong advice of Mr. Swinburne in concluding his paper need not be repeated.

NEW PATENTS—1889.

20627. "Improvements in electric distribution." W. M. MORDEY. Dated December 23.

20645. "New or improved means for protecting the metallic coating of telegraph cables from corrosion." J. A. L. DEARLOVE. Dated December 23.

20652. "Improvements in incandescence electric lamps." J. W. EDMUNDSON and W. CLARKE. Dated December 23.

20660. "An improved electric signalling apparatus." J. O. WINCKLER. Dated December 23. (*Complete.*)

20717. "Improvements in electric cams."* H. S. PRENTISS. Dated December 24. (*Complete.*)

20734. "Improvements in magneto-electric machines." R. HADDAN. (Communicated by C. F. Gillette, United States.) Dated December 24. (*Complete.*)

20751. "Improvements in electrical accumulators." F. MARX. Dated December 24.

* ? Cars.—EDS. ELEC. REV.

20752. "Improvements in the manufacture of electrodes for electric batteries." F. MARX. Dated December 24.

20797. "Improvements in pendants and other fittings for electric light." W. W. STRODE and C. G. GILL. Dated December 27.

20856. "Improvements in elements for voltaic batteries." D. G. FITZGERALD and A. H. HOUGH. Dated December 28.

20911. "Improved battery plates for storage batteries." A. E. WOOLF. Dated December 31. (*Complete.*)

20918. "Improvements in or appertaining to the method of and apparatus for generating and maintaining electric currents of constant, or approximately constant, quantity in circuits of varying resistance." W. P. THOMPSON. (Communicated by W. Stanley, jun., United States.) Dated December 31.

20955. "Improvements in dynamo-electric machines, in part applicable to electro-motors." J. J. WOOD. Dated December 31.

20962. "Improvements relating to the securing of rings, washers, collars, or other perforated objects to metal bars, rods, or the like by the use of electricity." H. H. LAKE. (Communicated by E. Thomson and H. Lemp, United States.) Dated December 31. (*Complete.*)

20971. "An electric exercising machine." O. IMRAY. (Communicated by the Electric Exercising Machine Company, United States.) Dated December 31. (*Complete.*)

20974. "A system of hydro-electric distribution." F. RYSSELBERGHE. Dated December 31.

20991. "Improvement in electric and magneto bells and apparatus to be used therewith." H. P. F. JENSEN and J. JENSEN. Dated December 31.

1890.

22. "An improved flower stand and electric light standard combined." Messrs. GRAHAM and BIDDLE. Dated January 1.

42. "Improvements in the manufacture of cables suitable for the distribution of electric currents." W. S. SMITH. Dated January 1.

57. "Shades for oil, gas, electric, candle, or other artificial lamps or lights." S. B. KIRSCHSTEIN and J. MANSERGH. Dated January 2.

58. "An improvement in or connected with incandescent electric lamps." H. GARDNER. (Communicated by W. Reid, United States.) Dated January 2.

61. "Improvements in breech mechanism for ordnance and electric firing arrangements." G. QUICK. Dated January 2.

81. "Improvements in coin-freed apparatus for supplying currents of electricity and other articles or objects." H. S. PRICE and H. J. DOWSING. Dated January 2.

113. "Improvements in electric meters." W. MOSELEY. Dated January 3.

135. "Improvements in alternate current motors." L. B. ATKINSON. Dated January 3.

175. "An improvement in electrical conducting wires and in the manufacture thereof." R. MANNESMANN. Dated January 4.

CORRESPONDENCE.

Fire Office Inspections.

Can any of your readers advise me if it is absolutely necessary to obtain the permission of the insuring fire office in order to be allowed *to think* even of using an artificial light?

Surely it is sufficient if one advises the office that the use of incandescent lamps *is* contemplated, and states the precautions he intends taking, and asks if these precautions meet with their valued (!) approval?

But no, it seems that you must first ask them to think about electric lighting before in any case deciding to use it.

Are there not many who think with me that these fire office inspections and controls are becoming a little overdone? I grant that a certain amount is desirable, but not too much. As an instance, what reliance can be placed on the inspector who, when inspecting a certain installation for the *first* time, finds fault with everything? Nothing will suit; all must be pulled about and altered "to suit the requirements," &c.; however, a week later the same gentleman (I am sure I was not mistaken) passed the chief part that had *not been touched*, using such expressions of approval as—Ah! that's very nice, very good!

I believe this experience to be by no means unique, and should like to know if there is any way of avoiding these little annoyances that cause at the time so much

disagreeable and undesirable friction between the contractor and his client?

Remonstrance.

Ferranti v. Edison.

I hardly like this heading, but it appears to speak the truth.

But we must not be too hard on the one who, indisputably, is for passing into new fields. Pioneers always meet with more or less natural difficulties in their work, but often suffer most, inwardly, from contemporaneous criticism. This criticism, however, is merely analogous to the crucible in refinery; but we must beware what pot we are heating, and not let the temperature get too high to melt it and lose its contents. Mr. Ferranti has already done excellent work with his high pressure currents, and he is really championing that system. "Nothing succeeds like success," and I am sure many of your readers, far from grudging him success in his venture, are desirous that he should succeed in his, after all, self-imposed task, if only for the reason that their operations will be affected by it.

I am sorry, however, that Messrs. Ferranti and Ince should have made such a terribly weak defence of their system in their two recent communications to a contemporary journal. This will mean some more heating of the crucible. Let Mr. Ferranti go on, and never mind what Mr. Edison nor anybody else may say; and let his wits be taken up in proving his system—a system which he probably knows more about practically than anybody else—not on paper, by falling into the platitudinarian style of argument, nor by quoting puerile amusements about experiencing pleasant sensations from two exposed terminals in his company's office, nor by attempting those gymnastic feats in which our good friends over the water so much excel, by stating that "we have had several accidents where men in the station have received a shock direct from the machine with a 2,400-volt alternating current, but not in one instance has death resulted."

The readers of this journal will regret that Mr. Ferranti should have made such a statement without giving some accurate details, because statements tending to mislead eventually create a great want of confidence in the public mind. Surely Mr. Ferranti does not mean to say, or go so far as to imply, that this potential is not a death-dealer? And, further, what an exhibition of uncertainty then is brought forward to be faced, when it is stated that the men get shocks from the machines. It will be reasoned thus: "The pitcher goes to the well, &c.," so we can only suppose that the ordinary "pickled" or unpickled man will some day get his last shock if the machines are capable of giving them.

Mr. Ferranti may know that he has a lot of outside sympathy in his work, including that of the writer, who, although he does not approve of high potential generators—that is, the dynamos—is quite in accord with the idea of transmitting electricity at the utmost useful potential, from point to point, through undisturbed or permanently fixed mains; he is more of the opinion that less risk, and hence greater confidence, would be effected by using lower potential dynamos; and if the energy be required to be transmitted to a distance through such a cable as Mr. Ferranti describes (the jointings of which is the weak point), to transform this lower potential current from the dynamos into a higher potential, by having a transformer or transformers at the generating station for that purpose; so that all parts requiring attention, moving parts, &c., would be at a potential which would be safe to human life; the transformers and the higher potential conductors being kept absolutely untouched, and away from any and every chance of danger. Say, for illustration, 10,000 volts with 100 ampères generated in the secondary coil of the transformer, from the primary supplied with 10,000 ampères and 100 volts, produced from ten alternating machines in parallel (they would synchronise), each giving out 1,000 ampères, or any less number of machines with increased current, and bring the 10,000 volts down to 100 or 200 volts for the mains from which to take off current to the houses, and this could be accomplished by having a greater number of transforming centres, which would cost comparatively nothing to maintain. The area which can be supplied at a maximum economy at 100 or 200 volts, is a matter of simple arithmetic.

But the mains, machines, and everything requiring touching or manipulating, must not exceed the 200 volts; no transformer to be placed in any house or building; and the station transformers to be under lock and key, or a hundred locks and keys, if necessary. The whole system, then, is safe, and still Mr. Ferranti can convey his current to London at 10,000 volts; but none of your plans of taking current into houses at 2,000 volts. The transformers must not see the light, nor feel the touch of anybody or anything; they must be looked upon, like in the Jewish Temple service, as the Holy of Holies, and, to be in their presence, to mean fear and trembling. The high potential conductor never to be touched for making branches, except to the transforming stations.

Personal comparisons are at all times odious, and I cannot, therefore, let these gentlemen (Messrs. Ferranti and Ince) free without calling their attention to this truth.

Sir William Thomson and Mr. Edison are both very good, excellent men; each in his own particular path has done much for us, the one giving us his depth of conceptions in the theory of vortices, and such like, and the other is an example of indomitable perseverance in wearing down practical difficulties in the application of anything and everything to useful ends; and both, like good citizens, always have an eye to the main chance. The world is certainly benefited by the labours of these two great men, and they, again, must be thankful from having benefited from the world; they will receive their reward if only by being remembered in the future, or they will "live," as the literary men have it; and I see no reason why Mr. Ferranti may not gain lasting honours for himself, if he sticks to his task.

I heard a good story, thus: "A cat is passing in front of a window, and there are two men (an Englishman and a German) engaged in the room or laboratory. The Englishman is distracted in his thoughts, and he cannot be consecutive with that cat on the window sill; the German is short-sighted and cannot see the cat, and is not disturbed, hence the German's chance of success in invention is enhanced by his inability to see far. Let not Mr. Ferranti be disturbed by any number of cats, even if they squall.

It is said that facts are against Mr. Ferranti. I can appreciate that statement when we classify the whole modern electric thought and machinery—the well done and the badly done—but it is not fair to an individual, whose work is not finished, to say that because his fellows have failed (through negligence, I consider), *he* must necessarily be considered to have failed.

It takes a thundering lot of blacks to make a white; but you cannot say to which either belong until you see both. And I would take this opportunity of bringing this fact in modern philosophy before many of your correspondents who talk about matter as though it were something really easily explained—that our knowledge is gained only by comparison; everything goes in the double, and what is not comparable is not explainable; and as long as we cannot compare matter it is as idle to attempt to explain it as to say that we know what we are ourselves. We have not seen Mr. Ferranti's work yet, the work he is anticipating and probably means accomplishing; and until we do see it, we should hesitate to pronounce any hastily formed opinions, but encourage him to go on.

I have referred to the Jewish temple; but I must be excused for so doing on the plea that Mr. Ferranti thinks it necessary to refer to periods anterior to the Christian era in speaking of his insulating material for his tubes. Why did not Mr. Ferranti tell us what it was? But I beg pardon—Mr. Ferranti is also a good citizen. Mr. Edison evidently knows nothing about it, so implies Mr. Ferranti. I will do a guess.

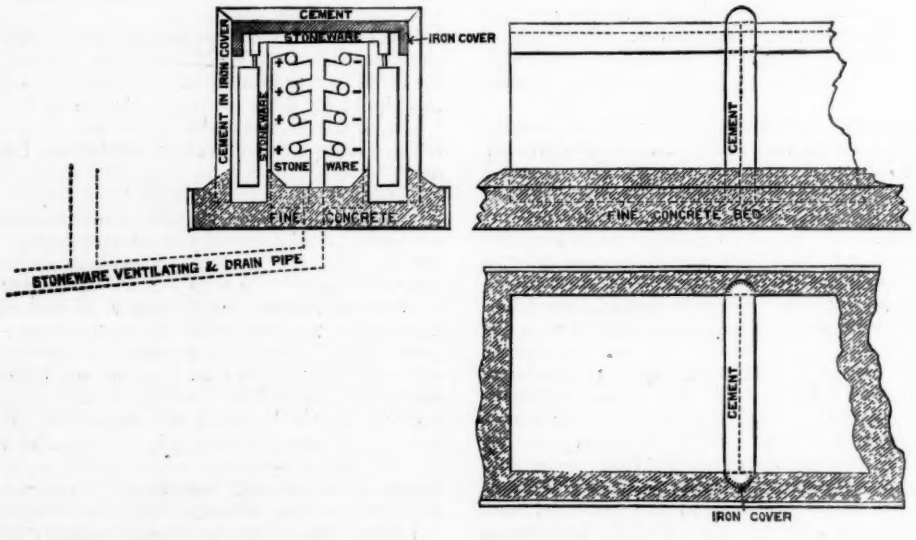
Mr. Ferranti did not mention Egypt; but what did the Egyptians want with insulating materials? I am off to Egypt now, like a good many more of our over-fed and sometimes overworked brothers. . . . . Arrived at Cairo and meet a countryman of mine in the "Garb of old Gaul," and, from his appearance, still retaining the "fire of old Rome." "What I want is to get a genuine mummy." "Oh yes," says he, and it is arranged with one of those other good citizens of Egypt, a place where you see them in their prime. Carefully packed up and brought home: "Ah, now my boy, you know something about the crust of the earth, what's that 'black stuff' smeared all over the cerements of your departed brother?" "Right—I have it!" "I've met you, or one of your tribe, Mr. Bitumen, before." "Have another look," says he, in his eye. "Light the gas, and see what I'm made of." I burn him. "By jove! there must be a lot of wax in you." Burns splendidly. "Oh yes; but I get thicker when you heat me, but do not burn me." "Do you though?" "I say, Mr. Wax, Mr. Bitumen! you are disappearing!" Yes; and the feeble voice said one word, "Residuum." When you get a last message from a departing friend, it is fixed very stably in your memory. Imagine walking down Fleet Street in the direction of these two exposed terminals, where you get the pleasant sensations, with two words on the brain—bitumen and residuum—with no end to the tribe of the first, and no limit to the meaning of the other. But I'll do as Dr. Johnson did, take many walks down Fleet Street, and when I think it down to its proper consistency [not the street], and those distracting cats do not bother me, I will call in at the nearest telephone exchange, and tell M. Edison all about it. But Oh!—Now somebody else guess.

James C. Richardson.

January 13th, 1890.

Two Suggestions.

I beg to enclose sketch, showing a modification of the design sent you on 6th inst., as another step towards the solution of a safe conduit for electric light wires, which will, I hope (owing to the importance of the subject) stimulate your readers and bring forth an efficient and satisfactory system, and thus solve this difficult and long standing problem.



You will observe that the side chambers are now in separate pieces, imbedded in cement, and intended to be of stoneware, which would be preferable to iron on account of insulation and less expense.

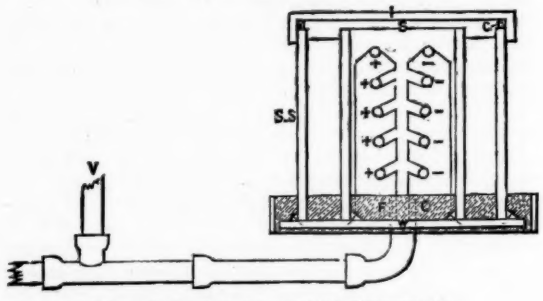
The inner cover would also be of stoneware, but it may be advisable to have the top, or outer cover, of iron as a protection against picks. As a prevention against gas accumulating in the side chambers might I suggest that a blow of compressed air be sent through, say, once a-day.

Permit me at this opportunity to remark that the patented device, described by Chas. W. Farquhar, in the REVIEW of 1st June, 1888, is, to my mind, a very practical one, and reflects credit on the inventor; but, would not the addition of an iron cover and side chambers be valuable?

January 8th, 1890.

Pardon me for again troubling you, but the enclosed sketch represents a further, and perhaps better, modification of the proposed conduit for electric light wires which may not be uninteresting to your readers.

My aim is to simplify the manufacture of the stoneware portion as well as the building of the conduit. This you will observe is attained by forming the conduit out of slabs secured in a bed of concrete.



I, iron; C, cement; S, stoneware; S, S, stoneware slab; F, C, fine concrete; W, wood; V, ventilation.

I may add that with a similar ventilating and draining arrangement for the two side chambers, it would dispense with the compressed air suggestion and make a very complete system of ventilation, but it may be inferred, why not connect all the chambers to one pipe and thus save expense.

I would say, inasmuch gas would be more apt to penetrate into the central chamber and this is what I should like to avoid. I presume there would not be any difficulty in baking the slabs so that they would be perfectly flat and free from warp; if so we might have to fall back on iron. Apologising for overdrawing upon your valuable space.

One Interested.

January 10th, 1890